INDO-SOVIET JOINT SPACE ODYSSEY

INDO-SOVIET JOINT SPACE ODYSSEY

SPACE CELL
AIR HEADQUARTERS

October 1985 (Asvina 1907)

Script: K.S. Ramamurthi

Pictures on Cover:

BAIKONOUR SPACE PORT: The space ship SOYUZ on the launching pad.

On the top left is the mission emblem, 'Surya' the Sun in a Chariot drawn by horses. The mission emblem is one of the badges which all the crew members wore on their space suits or work clothing. The other badges worn by the Indian Cosmonaut are the Indian tri-colour, the Ashoka Lion and the IAF badge.

Printed at Allied Publishers Pvt. Ltd. A-104 Mayapuri, Phase II, New Delhi 110064

CONTENTS

Sketches

I. Introduction

The launching on 3rd April 1984 of the first Indian cosmonaut, Sqn. Ldr. Rakesh Sharma into space from a Soviet cosmodrome fired the imagination of the Indian people as nothing else has in recent times. The space voyage for the first time ever by an Indian was made possible by over two decades of scientific research on space problems and the country's far-sighted decision to collaborate with the Soviet Union in space science and technology. This collaboration is nearly as old as space research in India and in the last twenty years, the nation has achieved a degree of self-reliance in space science and technology equalled or excelled only by a handful of other nations.

Jawaharlal Nehru began laying the solid foundations for scientific and technological advancement soon after India became independent. Thanks to the highly skilled technical manpower now available, India is able to design, develop and fabricate sounding rockets and satellites and would soon be able to place large spacecraft in orbit with Indian launching vehicles. The main thrust of the space programmes in the next five years would be to achieve self-reliance in spacecraft and launch vehicles. In the coming years, India's use of outer space is expected to make significant contributions towards solving major national problems like mass illiteracy.

The Indo-Soviet space odyssey will help India set up basic infrastructure and nucleus of expertise, although a totally indigenous manned space programme is still a few years away. The experiments conducted by Sqn. Ldr. Sharma are invaluable for building up the corpus of knowledge needed for the exploitation of the natural resources of the country. The remote sensing experiments in particular are expected to provide a measure of knowledge which conventional methods would have taken years to yield. According to Sqn. Ldr. Sharma, a large part of the Indian territory has been photographed. Normal aerial photography would have taken many years to achieve this and would have been several times costlier. But perhaps the greatest achievement of the odyssey is that, in one bold stroke as it were, it made a whole nation of 70 crore people conscious of the potentialities of space science.

II. Space Exploration

Just less than 30 years ago, the problem of cosmic flights and the building of artificial satellites of the Earth appeared highly fanciful. Only specialists were working, on the basis of calculations and experience gained through the employment of several experimental techniques, on designs of rockets to fly at altitudes of several hundred kilometres at stupendous speeds, such as are needed to put into orbit a man—made satellite of the Earth. By 1957, while technical difficulties were still encountered, it was possible to attain the required altitudes and speeds by multi-stage rockets.

The simplest multi-stage rocket is essentially a system of rockets, operating successively. To illustrate, a three—stage rocket is made up of three rockets which at first move together. At the start, the first and main rocket is put into operation. After it has accomplished its function, it detaches itself from the rest and, at that very moment, the second rocket goes into operation; when the latter has accomplished its function, it too is detached, and the third and last rocket begins to operate. As a result, it becomes possible to shoot up to the required altitude at the required speed, a special body—a satellite of the Earth—equipped with instruments for scientific investigation and for communication with the Earth.

What was a fanciful idea three decades ago was becoming closer to realisation by the middle fifties, thanks to the persistent work of devoted people during the previous decades.

The problems of space travel began to engage the attention of scientists all over the developed world in the last century. There is a long history of theoretical astronautics done in the Soviet Union and pre-revolutionary Russia. The Russians are the pioneers in space exploration. The quest for the secrets of space began as early as the last quarter of the 19th century when Kibalchich initiated the concept of rocket propulsion for space flight. Later, K.E. Tsiolkovsky, known in the Soviet Union as the father of astronautics, laid certain scientific basis for a practical solution of the problems of space flight. His "Study of Cosmic Space by Means of Reaction Apparatuses" was published in 1903. Theoretical research into the possibility of manned probes of outer space was conducted in the twenties. In his book "Space Rocket Trains", Tsiolkovsky expounded for the first time the idea of multi-stage rockets. Another talented scientist and engineer, F.A. Tsander, worked out the design of a space vehicle in 1922-23. He is believed to be the first man in the world to elaborate a method for theoretical calculations in rocket engineering, jet propulsion and other aspects of space flight.

Simultaneously with Tsander, Kondratyuk, a mechanical engineer, worked on space problems and produced in 1929 his book "Conquest of Inter-planetary Space", which was a comprehensive study of the problems of space flight. In the early thirties, designers started building the first rocket engines and rockets. The first Soviet liquid-fuel rocket engine, a prototype of the modern spaceship engines, was designed and built in 1930-31. High altitude rocket probing finally led to the launching of the first Sputnik on 4th October 1957. This was

the first man-made vehicle ever to go into space. A few months later, a second Sputnik was launched. A special hermetically sealed chamber in it contained a test animal, a dog called "Laika", measuring equipment to record the animal's physiological functions, and also equipment for regeneration, feeding and removal of the animal's excretions. Equipment designs took into consideration the requirement for the most stringent economy in size and weight, coupled with a minimum consumption of power. A radio-telemetring arrangement ensured recording of the pulse-beat and breathing of the animal, the arterial blood pressure and cardial biopotentials, as well as the temperature and the air pressure inside the chamber.

The dog "Laika", sent up aboard the Sputnik, had gone through preliminary training. It was gradually accustomed to protracted sojourns in special clothing, in small hermetically sealed chambers. The animal's resistance to the effects of vibration and some other factors was ascertained in laboratory conditions. After training over a period of several weeks, the dog was able to remain calm inside the hermetically sealed chamber, thus enabling the necessary scientific investigations to be carried out.

After the Sputniks, a series of space rockets were sent up. One of them became the first artificial planet in the solar system; another hit the surface of the moon and delivered there a pennant with the Soviet coat-of-arms marked "September 1959". The third rocket, launched on 4th October 1959, placed into orbit around the moon an automatic station which supplied for the first time in the history of astronomy, photographs of the reverse side of the moon hidden from the human eye.

The new era of man's flight into space opened only after a number of automatically controlled spacecraft had been sent into space and brought back to earth. The first such spacecraft, an unmanned Vostok, was orbited by the Soviet Union on 15th May 1960. The second Vostok, with the dogs Belka and Strelka on board, left on 19th August 1960, and after a whole series of medico-biological experiments, returned to the Earth safe with the dogs. The subsequent launchings of three other spacecraft between December 1960 and March 1961 helped further to test and improve the control systems and to ensure that man could safely travel in space.

It was this Vostok generation of spacecraft which first put a man in space. Major Yuri Alexseyevich Gagarin, the first man to go into space, took off in Vostok-1 on 12th April 1961 on an epoch making 108-minute flight round the Earth. The training centre for cosmonauts situated at Star City near Moscow is named after him.

Since then, some ninety or more manned space flights have taken place. Marking the intervening years has been a race between the United States and the Soviet Union for space superiority. These years have been crowded by an increasing number of astral missions by the United States and the Soviet Union. The U.S. flights were manned exclusively by Americans. The Soviet Union has sent up eleven cosmonauts from other countries. Squadron Leader Rakesh Sharma was the eleventh cosmonaut under the Intercosmos programme, after Czechoslovakia, East Germany, Poland, Bulgaria, Hungary, Cuba, Viet Nam, Mongolia, France and Rumania. He was the 136th cosmonaut, his predecessors being 66 Americans, 59 Soviets and ten other Intercosmos spacemen.

The years of manned flights began on a note of intense competition with the United States and the Soviet Union blasting off rockets one after the other. Till March 1965, the Soviet Union had sent up 11 cosmonauts to the six sent up by the Unites States. The Soviet cosmonauts included the world's first woman consmonaut, Valentina Tereshkova, who went on a 68-hour trip aboard Vostok-6 on 16th June 1963.

Between 23rd March 1965 and 12th September 1966, the United States got the lead, packing in nine flights with 15 cosmonauts. The year 1966 was a particularly fruitful year for the United States with eight of its spacemen going up.

However, 1967 turned out to be disastrous for both the Soviet Union and the United States. Americans Virgil Grissom, Edward White and Roger Chaffee were burnt to death when their Apollo spacecraft caught fire during ground test on 27th January 1967. Soviet Union's Vladimir Komarov was killed on 24th April 1967 as his re-entry parachute failed during return from a 24-hour space trip aboard the Soyuz-1. During the Gemini-IV mission from 3rd to 7th June 1965, White had become the first American to space walk (EVA) and Komarov had participated in the spaceflight on 12th-13th October 1964 in the first three-man craft Voshkod-1. Another fatal accident for the Soviet Union took place on 6th June 1971 when the crew of Soyuz-II was killed on landing due to depressurisation. The three cosmonauts on board, Georgi Dobrovolsky, Vladislav Volkov and Viktor Patsayev had spent 23 days in space after docking with the Salyut.

Both the United States and the Soviet Union created a number of records in space. The Soviet Union concentrated on conducting on-board experiments. The United States strived for a place on the Moon. Apart from having sent the first man and woman into space as well as the first three-man craft, the Soviet Union was also the first to demonstrate that space walk was possible. Soviet cosmonaut, Alexei Leonov took the maiden space walk for ten minutes during the Voshkod-II mission on 18th—19th March 1965, about three months ahead of the American, Edward White.

In December 1968, the United States sent a manned flight around the Moon for six days aboard the Apollo-8. This was followed by three more cosmonauts who made a descent to within 14 kilometres of the Moon in May 1969, two months before Neil Armstrong and Edwin Aldrin landed on it. The feat, accomplished on 21st July 1969 was hailed as a "giant step for mankind". This was followed by other Apollo missions. Two American cosmonauts, Charles Conrad and Richard Gordon spent seven hours on the Moon in November 1969 and brought back 20 kg of Moon samples. Two years later, three more cosmonauts brought back a heavier load of 97.5 kg of samples.

The Soviet Union sent up the unmanned Luna 16 on 12th September 1970 and Luna 17 on 19th November 1970. Luna 16 picked up Moon soil samples and returned to Earth on 24th September 1970. Luna 17 carried the Moon buggy, Lunokhod 1, which roved the surface of the Moon. It was an eight-wheeled vehicle, carrying apparatus to study the lunar surface and transmit information back to the Earth.

The Soviet Union sent up the first international crew in March 1978. Vladimir Remik of Czechoslovakia accompanied Alexei Gubarev of the Soviet Union on a seven-day mission. All the while, the Soviet Union had been conducting experiments on joint manual control manoeuvres, docking manned crafts and setting space endurance records.

The years 1976 to 1979 saw 18 flights from the Soviet Union, one following the other in quick succession. On 12th April 1981, less than a month after the Soviet Union had sent a Mongolian cosmonaut into space, the Americans John Young and Robert Crippen blasted off aboard the space shuttle "Columbia" and spent 54 hours in space, completing the first ever successful flight of a re-usable space vehicle. More than a year later, Anatoly Berezovoy and Valentin Lebedev went up on the Soyuz T-5 and stayed put at the Salyut 7 complex, to create an all-time record flight of 211 days. Since then, the United States has sent up the "Challenger" eight times.

On 8th February 1984, the Soviet Union launched Leonid Kizim, Vladimir Voloyov and Oleg Atkov on Soyuz T-10. The trio played hosts to the first Indian cosmonaut Squadron Leader Rakesh Sharma and his two other fellow cosmonauts, both Soviet citizens. These three cosmonauts continued with their space mission after the return of the Indian cosmonaut to set yet another record in space endurance flight. They were in space for 238 days.

III. From Toy Rocketry to Man in Space: India's Saga

The blast-off of Soyuz T-11 on 3rd April 1984 from Baikonour cosmodrome in Soviet Kazhakhistan with an Indian, Squadron Leader Rakesh Sharma on board, marks a distinct stage in India's progress from toy rocketry to a position of self-reliance in space technology. Thanks to over two decades of purposeful development, Indian scientists now have the know-how to design, fabricate and launch spacecraft several tonnes in weight. India has worked in close collaboration with several countries to achieve the degree of self-reliance it has.

India's great advances in the use of satellite communication made it possible for the Indian people to watch on their television sets Rakesh Sharma soaring into space, carrying out scientific experiments and conversing with the country's Prime Minister. India's space exploration is a fascinating saga with the consistent aim of achieving self-reliance in all branches of space science.

It was in the early sixties that the first tentative step towards space research was taken when a few Indian scientists launched a tiny rocket, about the length of a pencil from the compound of a Church in Trivandrum. Space exploration had its formal start with the launching of sounding rockets from a fishing village called Thumba, near Trivandrum.

The Thumba Equatorial Rocket Launching Station (TERLS) was set up in 1962 with support from the Soviet Union, the United States and France. TERLS is now an "international range" under United Nations sponsorship which is available for use by the whole international scientific community. Thumba, being on the geomagnetic equator, is a unique launching station for carrying out intensive investigations on the equatorial electrojet phenomena and on the behaviour of the equatorial ionosphere. An additional advantage of the location is the low cosmic ray induced particle background, a condition which enables scientists to perform valuable particle and high energy astronomy experiments. On 21st November 1963, a two-stage Nike Apache Sounding Rocket took off from Thumba marking the beginning of India's space odyssey.

It was realized early that space science and technology held great potential for meeting various national needs, such as rapid development of mass communication and education and timely survey and management of the country's natural resources. The objective of the Indian space programme was defined as to initiate, develop and master space science and technology to exploit their potentialities for the socio-economic development of the country.

The Space Commission was set up in 1972 with a view to promoting the development and application of space technology and space science for social and economic development. The responsibilities of the Commission include the framing of Outer Space Policy and its

implementation. The Department of Science is responsible for the execution of activities in space applications, space technology and space sciences through the Indian Space Research Organisation (ISRO). Both the Department and ISRO have their headquarters in Bangalore.

The responsibilities assigned to the four Centres under ISRO highlight the peaceful and developmental orientation of the Indian space programme. The Space Application Centre in Ahmedabad is the main Centre for activities relating to application of space science and technology for practical uses such as telecommunication, TV broadcasting and reception via satellite, survey of natural and renewable earth resources using remote sensing techniques and studies in space technology and satellite geodesy. The ISRO satellite Centre in Bangalore conducts research and development in satellite technology. It designed and fabricated the first Indian satellite, **Aryabhata** as well as **Bhaskara** I and II, **Rohini** and satellites for the Ariane Passenger Payload Experiment (APPLE). The Vikram Sarabhai Space Centre in Trivandrum is the main Centre for research and development in space technology, namely, sounding rockets and launch vehicles. This Centre also operates and maintains TERLS.

The SHAR Centre in Sriharikota island off Andhra Pradesh has facilities for launching large multi-stage sounding rockets. It is also a satellite launching station. The main ground station for receiving data from and for control of satellites is located in Sriharikota. SHAR has facilities for static test of launch vehicle stages and for large scale production of rocket propellants. In addition to these, there is the Auxiliary Propulsion System Unit in Trivandrum and Bangalore and the Civil Engineering Division in Bangalore with its offices in all ISRO Centres. The National Remote Sensing Agency (NRSA) at Hyderabad is helped by the Department of Space in tapping the potential of remote sensing technology in the survey of natural resources. The activities of NRSA, which is an autonomous body, include the operations of the Landsat Ground Station at Hyderabad, the Research Flight Facility at Bangalore and the Photo-Interpretation Institute at Dehra Dun.

Collaboration with the Soviet Union has played an important role in building up India's capability in space technology. As long ago as 1963-64, an agreement was signed between the Hydrometeorological Services (HMS) of the Soviet Union and India's Department of Atomic Energy under which regular weekly meteorological soundings have been conducted from Thumba using Soviet M-100 rockets. The M-100 programme has contributed to the understanding of various scientific phenomena like the climatology of upper air parameters in India, regional features of long term oscillations of the upper atmosphere, phase relationships between these oscillations and possible effects of upper air conditions on the troposphere, particularly during the monsoon.

India's probe into space increased in tempo and quality with the signing of the agreement with the Soviet Union on 10th May 1972. It marked a new and significant phase in space research for peaceful purposes. Under this agreement, the Soviet Union agreed to launch an Indian built artificial earth satellite from a cosmodrome in the Soviet Union. Accordingly, the first Indian satellite **Aryabhata**, named after the ancient Indian astronomer and mathematician, was designed and fabricated with technical assistance provided by the Soviet Union. It was launched on 19th April 1975 by a Soviet rocket from a Soviet cosmodrome. It carried three scientific payloads, for investigation of intense X-ray sources

and for exploring neutron and gamma ray emission from the Sun.

Aryabhata helped India establish a firm base in satellite technology. After **Aryabhata**, ISRO designed and fabricated with Soviet assistance the two experimental earth satellites, **Bhaskara** I and II. **Bhaskara** I was launched on 7th June 1979 from a Soviet cosmodrome. Meant for earth observation experiments, the satellite was similar to **Aryabhata** except for the payload which consisted of radiometres and TV cameras fabricated by the Space Applications Centre, Ahmedabad. **Bhaskara** I was shut down in March 1981 after achieving the mission objectives. **Bhaskara** II, an improved version of **Bhaskara** I was launched on 20th November 1981 with satellite microwave radiometer payload, tape recorders, data collection platforms and solar cells.

On 18th July 1980, India's first generation launch vehicle SLV-3 put a 35 kg Rohini satellite into a near-earth elliptical orbit from Sriharikota. This was the culmination of about seven years of development effort. Rohini Satellite (RS-I) was basically a payload which evaluated the performance of the fourth stage of SLV-3. The 22.7 metre long SLV-3 is a four stage solid propellant vehicle with a launch weight estimated to be 17 tonnes. Its major sub-systems are four solid propellant rocket motors to provide propulsive energy; the inter-stages connecting the forward skirt of a stage with the rear skirt of the next stage and housing control, guidance electronics and pyro-subsystems, inertial guidance and control systems to steer the vehicle along a pre-determined trajectory and a heat shield to protect the fourth stage and the satellite from the aerodynamic heating during initial flight through the atmosphere. This was the launch which made India the seventh nation in the world to have orbited an earth satellite with its own rocket, the others being the USSR, the USA, the United Kingdom, France, Japan and China. It was the second experimental flight known as SLV-3-E-02. The first one, SLV-3-E-01 which took place from SHAR on 10th August 1979 was only partially successful. The second experimental flight was followed by what is called the first developmental flight (SLV-3-D1) on 30th May 1981. Preliminary data showed that the flight was a success though some deviations were observed from the prescribed performance. The satellite RS-D1 with a landmark sensor was placed into an orbit of 181 × 425 Km and survived for nine days only.

The second development flight SLV-3-D2 was launched from Sriharikota on 17th April 1983. It was unique in the sense that a high technology feature was included in the vehicle so that it could reach a higher altitude than the previous missions and also put the satellite into a higher orbit. This could ensure that it would not have less than the expected life span. The high technology feature was a new rocket motor incorporated in the fourth stage of the vehicle. The new motor was described by Dr. Vasant Gowarikar, Director of the Vikram Sarabhai Space Centre as "one of the most sophisticated in the world". The motor, called Kevlar motor (as it is enclosed in a very light fibre casing of Kevlar material) aimed at injecting the satellite into higher orbit. Another distinctive feature was that the Rohini Satellite carried a two-band imagery system known as the SMART sensor intended to help develop methodology for identification and classification of various ground features like snow, cloud, water, vegetation etc.

The next major Indian objective is a Polar Satellite Launch Vehicle (PSLV) designed to launch 1000 kg class satellites into Sun-synchronous polar orbits. With such a vehicle, India will become self-reliant in the matter of launching remote sensing and meterological

satellites. PSLV will be developed along with a parallel programme of quickly improving the present SLV-3 into a more advanced version called ASLV, the Augmented Satellite Launch Vehicle, and using it regularly for launching 150 kg class satellites for scientific and technological applications.

As a result of experiments by **Bhaskara** I and II valuable information was obtained on ocean surface winds, movements of cyclones and depressions and on the onset of the monsoon. Microwave imagery has provided information on the precipitation of rain and means to identify snow cover, agricultural land and forested areas. Study of geological features have shown that space imagery can be used for marking rock types. It has been possible, in addition, to distinguish fallow land from cultivable land and tropical moist desiduous forests from dry temperature forests. Thus, through the imagery obtained from **Bhaskara**, ISRO scientists have been able to establish the methodology of data processing, analysis and interpretation.

The gathering of such extensive data was made possible by the setting up of two telecommand stations, one at Bears Lake (USSR) and the other at Sriharikota to provide tracking, data reception and command facilities for **Aryabhata** and **Bhaskara** I and II. Satellite tracking has been used extensively for geodetic applications. Under an agreement between the Soviet Academy of Sciences and ISRO, the Soviet Union has supplied India an AFU-75 camera and laser equipment for installation at Kavalur in South India. It now forms an important element of the ISRO tracking network.

Planning and implementation of a satellite based remote sensing system for earth resources survey has been undertaken. The first of the series of Indian Remote Sensing Satellites (IRS-1A) is scheduled for launch in 1986. The Lok Sabha was officially informed on 21st March 1984 that the existing facilities in the National Remote Sensing Agency for acquisition and dissemination of data acquired from sensors on aircraft and on satellites are proposed to be augmented for meeting the IRS requirements.

The main aim of the country's space programme during the Seventh Plan would be to speed up its transition from competence-building, useful demonstrations and experimental missions so far to semi-operational and operational systems geared towards self-reliant use of space technology for national development. Such use would include satellite communication, satellite remote-sensing for resources survey and management, environmental monitoring and meteorological services and development and operation of indigenous satellite and launch vehicles to provide these services.

The late Prime Minister Mrs. Indira Gandhi, under whose leadership India has achieved the capability to launch space vehicles told the Parliamentary Consultative Committee for Scientific Departments in New Delhi on 28th April 1984 that the Seventh Plan envisaged the launching of the Augmented Satellite Launch Vehicle (ASLV) from Sriharikota in 1985, orbiting of an Indian remote sensing satellite from the Soviet Union in 1986 and the first launch of the Polar Satellite Launch Vehicle (PSLV) from Sriharikota in 1988. The launch of the INSAT-1C from the United States was also scheduled in 1986 and the launch of the first INSAT-II (Proto-INSAT) satellite in 1988-89.

Dedicating India's national satellite systems to peace and service of the people, Mrs. Gandhi said in Hassan, on 11th February 1984, that the country was not in space for any

reason other than peace. It was an essential investment for the future. She said that a country did not need to be rich to go ahead with science; it was progress in science that made a country rich.

Rakesh Sharma's odyssey symbolises India's efforts to acquire a clear understanding of the problems and potential of space flights. Some of the experiments conducted by him have relevance for any goals that Indian space scientists may set for themselves in the future. For instance, photographs taken during the remote sensing experiments, "TERRA" are expected to yield valuable information about the country's natural resources. Images collected as part of the experiment relating to remote sensing will be analysed to obtain information related to geology, hydrology, cartography, land use, forestry and other resources.

IV. Joint Manned Space Mission

(a) The Idea

It was the world's first cosmonaut Yuri Gagarin, who, during his visit to India in 1961, predicted that one day it might be possible for Soviet and Indian cosmonauts to explore the unknown realms of space together. The idea of an Indian in space was revived by Boris Petrov, Chairman of Intercosmos, in May 1978 when he said that India had the expertise and industrial base to put a man in space in the not-too-distant future if it wanted to. The idea was again revived by the late Soviet President Leonid Brezhnev in Moscow in 1979 and repeated during his visit to India in December 1980. A year later, the late Prime Minister Mrs. Indira Gandhi announced in Parliament India's acceptance of the Soviet offer to train Indian cosmonauts and send one of them to the Soviet orbital station of the Salyut-series. The responsibility of implementing the project codenamed "Pawan" was vested with the Chief of the Air Staff, the Indian Air Force (IAF).

A challenging opportunity presented itself to the IAF which celebrated its Golden Jubilee in 1982. The IAF made its debut on 8th October 1932 with a modest fleet of four Westland Wapiti aircraft and a complement of six officers and 22 airmen. Since then, it has grown into a highly professional force, equipped with advanced aircraft systems manned by officers and airmen trained to handle the most sophisticated equipment. The IAF, which is responsible for the country's air defence, has gained rich experience over the years in the operation of aircraft and aerospace systems. It was the first Air Force in Asia to fly jets and has been maintaining this lead by operating more and more sophisticated and advanced supersonic aircraft. The Air Force has on its inventory aircraft which operate almost to the fringes of space. It has been operating, with distinction, many types of Soviet aircraft and Soviet electronic systems since 1965. A long and fruitful association between the Air Force and Soviet aviation technology was now being extended to space technology and the IAF was understandably excited over the prospect.

(b) Selection of Cosmonaut Trainees

The IAF was entrusted with the task of seeing the project "Pawan" through because an aviator is considered the most eminently suitable person for space experiments. This is only natural since space is a projection of air, and one starts flying in the air before graduating into space. Cosmonauts all over the world have been members of the Air Forces of their countries. The first cosmonaut, Yuri Gagarin, was a pilot of the Soviet Air Force. Cosmonauts from other countries taken into space by the Soviet Union were also members of their Air Forces. Training for flying into space is of a type which is very close to the one given to an ordinary pilot in the Air Force, although a spaceman may not pilot a spacecraft in exactly the same manner as an airman pilots an aircraft.

The IAF had to select two of its best men to be trained in the Soviet Union for the memorable experience in space. While both were to undergo the full course of training, only one of them was to ultimately go into space, the other being in the back-up team.

Some of the important qualifications laid down jointly by the Indian and Soviet authorities for the research cosmonauts were: excellent to above average gradings in flying on supersonic fighter aircraft; preferably a test pilot, a good knowledge of engineering and technical subjects so as to have a sound appreciation of the complex scientific systems in the capsules; and a high standard of physical fitness, just as all fighter pilots have to be physically very fit. The latter was one of the very stringent requirements. Other aspects, such as age and knowledge of Russian, were also taken into account. The age limit laid down was between thirty and forty so that they would be at the prime of their health and they would have a long useful period after their achievement.

With these criteria in mind, a short list of 40 candidates from among 150 considered eligible was drawn up by an Air Force panel. The list was narrowed to two after three successive medical check-ups, one of which was held in the Soviet Union. The two who made it to the top were Wing Commander (now Group Captain) Ravish Malhotra (40) and Squadron Leader Rakesh Sharma (35). They commenced training at the Yuri Gagarin Training Centre in Star City near Moscow in September 1982. The Star City perches amidst idyllic sorroundings and a Soviet fighter aircraft mounted on marble, with the inscription "Long Live our Air Force", guards the intersection outside the entrance.

(c) The Making of a Cosmonaut

The training of cosmonauts at the Yuri Gagarin Centre follows three main streams, namely spacecraft technology and control operations, scientific and space experiments and physical conditioning for space flights. The entire training programme extends over a period of about 18 months and is broadly divided into two phases with a four-week break between the two. Since all training is imparted in Russian, a thorough grounding in the language is included in the first phase of training. The candidates go through a course of instruction in three other basic categories—theoretical, practical and bio-medical.

In the theoretical category, the trainees are taught among other things, flight dynamics, space navigation, computers, radio-active protection and still and cine camera operations. The training in the technical category includes study of the designs of the Soyuz and the Salyut space stations, simulator practice session, launch complex, mission programme and flight documentation. Extensively using simulators, the trainees undergo rigorous physical conditioning and experience zero gravity created antificially by an aircraft performing special manoeuvres. They also have sea-survival training to familiarize them with escape and survival procedures in case of an emergency splashdown in the sea. During simulator training, the candidate cosmonauts practice procedures connected with launch, docking with the orbital station and re-entry into the earth's atmosphere. Physical training to prepare the body for all the flight conditions is carried out in a centrifuge. Training in the hydrolaboratory (swimming pool) is done if extra vehicular activity is planned during flight. Another important element in the first phase of the training, conditions the cosmonauts to combat disorientation and motion sickness.

During the second phase, cosmonaut candidates are trained as part of a crew of cosmonauts for a particular mission. For the Indo-Soviet manned mission, the two Indian cosmonauts were trained as two crew sets along with their Soviet counterparts on the complete mission profile, including installation and calibration of equipment, the actual conduct of the scientific experiments, logging and recording of results and other activities. The two crew sets were:

Crew No: 1
(a) Col. Yuri Vasilivich Malyshev
(b) Sqn. Ldr. Rakesh Sharma
(c) Genadi Mikhailovich Strekalov

Crew No: 2
(a) Col. Anatoly Nikolaivich Berezovoi
(b) Wg. Cdr. Ravish Malhotra
(c) Georgi Mikhailovich Grechko

The main and back up teams were formed in September 1983 when crew-wise training commenced. Sqn. Ldr. Rakesh Sharma was assigned to the main team and Wg. Cdr. Ravish Malhotra to the stand-by team.

The main and back-up teams continued their training until the actual launching of the spacecraft with both the groups fully prepared to go into space for the final mission. The two teams had strenuous sessions on the Salyut Space Station Simulator and the Soyuz Space Vehicle Simulator. There were also regular training sessions on the Docking Simulator.

Formation of crews was announced simulatenously by the CAS in Delhi and Gen. Vladimir Shatalov in Star City. Composition of the crews was confirmed by Gen. Shatalov at a ceremony to mark the end of training. By then the flight engineer of the main crew, Nikolai Rukavishnikov, had been replaced by Genadi Strekalov. As per procedure, the final reconfirmation regarding crew composition is provided by a Soviet Government Commission on the day prior to the launch.

By then the technical commission evaluated the final training tests which had been conducted earlier and approved members of both crews. Gen. Shatalov said that the order of priority between the two teams could be reversed if any of the three members in the main crew fell sick or was disabled for any reason. "But", he added, "we are absolutely sure that either of the team will accomplish the mission".

Sqn. Ldr. Sharma was asked in the course of a Press Conference in Star City on 15 March 1984, as to what made a good cosmonaut. His answer: "He should have his feet firmly on the ground. He should have a kind of stability and confidence in himself so that under stress he produces the kind of work expected of him. The work is costly and cannot be repeated".

Asked for message to their families and friends back in India, Sqn. Ldr. Sharma said: "After many sessions in simulators and completing other courses of training, we are on time for the mission. We are sure we can fulfil the mission and carry out our responsibilities. All the people of the world will see the flight as a demonstration of Indo-Soviet friendship".

Wg. Cdr. Malhotra said: "All of us are anxiously waiting for the launch and, more so, because it will mark an important step India is taking in outer space. Our wish is to complete the experiments successfully before returning from our mission".

Thus the final selection of Sqn. Ldr. Sharma for the flight was confirmed from the launch complex Baikonour on 2nd April 1984. Wg. Cdr. Malhotra immediately congratulated "Rikki" (as Sqn. Ldr. Sharma is popularly called) and wished him a successful space voyage adding: "I will be there to receive you when you come down to Earth again".

Sitting under a banner, which said in Hindi, "Soviet-Bharatiya Maitri Ki Jay" (Victory for Indo-Soviet Friendship) and behind a glass germ-proof screen, Sqn. Ldr. Sharma said: "I am happy to have this honour".

V. Into Space—The Unknown Frontier

Space flights demand highly sophisticated ground and flight infrastructure and the highest degree of accuracy in operating it. In the course of the years, the Soviet Union, like India in recent times, has created facilities, both hardware and software, which have put it on top of the space-faring nations. The cosmodrome for launching rockets and the equipment to service the space stations and the spacecraft are of immense complexity which testify to the Soviet Union's technological advancement.

(a) **Baikonour Cosmodrome**

The Baikonour Cosmodrome, situated in Soviet Kazhakhistan, was built as long ago as 1955, a full six years before the first-ever man was sent into space. It is equipped with all facilities for the launching of rockets and has been the principal launch base for all Soviet launches since 1955. The Cosmodrome consists of an integration and test building for the launcher rocket, launch pads and observation rooms. Facilities, such as the Cosmonaut preparation centre, laboratories and community amenities such as schools and stadia, are located about 10 km away.

Before a rocket is ready for launch, its different components, such as various stages of the launch vehicle are thoroughly checked in the test buildings. They are then sent to the launch pad where they are assembled horizontally as a complete system. The launch installation is constructed as a semi-underground complex to provide protection against heat. The complete system consisting of the spacecraft and rocket is then fully tested as a whole. It is then lifted into a vertical position by means of hydraulic jacks. Pneumatic thermostatic control ensures that the equipment and gas temperature are within specifications. Connector sealing is done by evacuating the air and creating a vacuum. Finally, the on-board spacecraft systems, such as remote controls and electrical supply are checked.

After making sure that all systems are functioning well, the rocket is filled with propellants which are liquid oxygen and kerosene, pumped in by remote control after prior refrigeration of the LOX element. When this operation is complete, vertical and azimuth positions are finally checked. The Cosmonauts enter the spacecraft two hours and thirty minutes before the launch. The final sequence of operation is then initiated.

The launch time is then programmed to an accuracy of one hundreth of a second. Final checks are then carried out and data recording is initiated. If all has gone well thus far, one minute before "lift off", the operator switches to the launch position. At this moment, topping of the propellant tank ceases, the drainage lines are closed, and the supports are withdrawn from the rocket. The turbo pumps are activated and the ignition system is started in the combustion chambers of the first and second stage engines. When the engine thrust exceeds the weight of the launcher, which is about 300 tonnes, the lift-off takes place and the launch vehicle soars towards space. Almost nine minutes after the lift-off, the third

stage separates from the spacecraft. With this, the control of the Cosmodrome over the mission ceases and the spacecraft is handed over to the Flight Operations Centre of the mission.

(b) Flight Operations Centre

The Mission Control Centre (MCC) takes over control of the mission as soon as the Cosmodrome terminates control over the launch. It is located at Kaliningrad, close to Moscow. The spacecraft and the space station orbiting in space are controlled from this Centre. Mission control is effected through a sophisticated and elaborate communication system between the ground control stations, the orbital space station and the transporter spacecraft during different stages of the mission. Helping the mission control keep a constant watch over the flights, on wide screens facing the entrance, are seven ground tracking stations spread all over the Soviet Union and also tracking ships stationed in the Atlantic and the Pacific. Each station has 20 channels for different kinds of communications with the Operations Centre and is equipped with computer which can carry out 50,000 operations a second. The communication system also makes use of MOLYNA communication satellites. These communication links ensure monitoring of spacecraft parameters, conveying operational orders and uninterrupted audio-visual exchange of information with the crew throughout the mission. In case of emergencies, the zone of radio communication or visibility can be widened.

Mission Control Centre, which is responsible for operational control of the various space missions, collection of data and arranging training launches and rescue, communicates with the mission operations room of the space station and the operations room of the supply vehicle for flight control of a space mission. This facility is capable of simultaneously managing the flight of several spacecraft using information from the tracking stations by telephone, telemetry or television. The mission is controlled by a flight director under whom flight programmers, spacecraft system specalists, designers, ballistic experts, telecommunication controllers, doctors and others actively participate in the control of the mission. Each one of them is provided with his own means of communication at a separate work place.

The mission of the spacecraft is displayed on a control screen and personnel in the operations room monitor the transmission of radio commands as well as their reception on board while the Centre's computers automatically process the data as they are received. Specialists carry out detailed analysis of the functioning of the different systems. If something goes wrong, the specialist responsible for global analysis studies the implications of the snag on the operation of the spacecraft and suggests appropriate corrective measures to the flight director. These are carried out by the programme planning specialist. A simulator identifies any possible failures. All this time, uninterrupted radio communication is maintained between the operator and the cosmonauts.

(c) The Space Station and Transport Spacecraft

Sqn. Ldr. Rakesh Sharma and his Soviet crewmates were transported to Salyut-7 orbital

station by the Soyuz-T 11 manned spacecraft. However, on completion of the mission, they returned to earth in the Soyuz-T 10 which was already docked with the Salyut and in which the host crew had been launched. In this, they followed previous practice. The spacecraft is 6.98m long and weighs about 6.8 tonnes. It has two solar panels which are deployed during the orbital phase. The spacecraft consists of a descent module, and orbital compartment and another one for equipment. The control of the spacecraft is by an on-board computer which integrates the flight parameters of the spacecraft and ensures autonomous control. The cosmonauts are kept informed of the progress of their spacecraft and can, at any time, take over manual control both during orbital-flight and during re-entry into the atmosphere.

The "Progress" spacecraft is the unmanned version of Soyuz-T, a space version of what on earth would be called a cargo vehicle. It takes supplies to the cosmonauts, ferries the scientific equipment and removes the waste and used equipment from the space station. The "Progress" spacecraft is slightly heavier than the Soyuz-T, weighing seven tonnes. The spacecraft is divided into a cargo bay which also has a mating device for docking with Salyut, a compartment for additional fuels and another one for equipment. Throughout its flights the internal environment (astmosphere, temperature) is controlled to preserve supplies. While the spacecraft is itself remotely controlled from the Earth, the supply operation for food, fuel equipment etc. from the cargo bay is controlled from the Salyut space station. The "Progress" spacecraft is capable of delivering 2300 kgs of supplies and 1000 kgs of propellant and gaseous substances in near-earth orbit. The cargo spacecraft can also be used as a space tug to correct the orbit of the scientific complex through its own engine system.

Both the Soyuz-T manned spacecraft and the unmanned "Progress" are launched by a 3—stage Soyuz rocket which is 49 metres long. The first stage consists of four strap-on boosters, 19m in length, each developing 102 tonnes of thrust. The second stage, which is 28m long develops 96 tonnes of thrust. The final stage, which is 8m long, develops 30 tonnes of thrust. At launch, both the first and second stages start up simultaneously and lift the 300-tonne rocket.

There were three hosts waiting for the three visiting cosmonauts in the space station Salyut-7. The three hosts were Commander Leonid Kizim, flight engineer Vladimir Solovyov and heart specialist Dr. Oleg Atkov. They were safely ensconced in the new orbital complex formed by the docking of their spacecraft Soyuz-T 10 with Salyut-7. The docking took place 26 hours and 36 minutes after their launch from the Baikonour Cosmodrome on 8th February, 1984. The spaceship's approach to the orbital station was carried out automatically and the berthing and docking of vehicles was done manually by the crew.

Salyut-7 is a second generation space station which was launched in near-earth orbit on 19th April 1982 and has had two previous crews working aboard on two long duration missions of 150 days and 211 days. It has also received two visiting crews upto now.

The Salyut-7 space station resembles an assembly of two cylinders of different diameters The maximum diameter of the station is 4.15m. A manned transporter spacecraft of the Soyuz-T type or an automatic (unmanned) cargo spacecraft "Progress" can dock at either end of the space station. The overall length of the orbital scientific research complex consisting of Soyuz-T at one end and "Progress" at the other is 29m. The overall weight of

this complex is 32,500 kgs. The Space Station, Salyut-7 by itself is 15m long and weighs 18,900 kgs. Its span with solar panels deployed is about 17m.

The interior of Salyut consists of a series of compartments and control sections along its length, because of its cylindrical shape. The station consists of five modules; the adapter module, the work module, the scientific payload module, the air lock and the service module.

The work module carries the main control equipment of the station. It is from here that the crew controls the station and conducts the majority of experiments. It consists of two cylinders, one of diameter 2.9m and length 3.5m and the other of diameter 4m and length 2.7m. The cosmonauts rest, sleep and eat in this compartment which has orientation controls for astronavigation as well as operation of the scientific equipment, controls for radio communication with the earth, and controls for house-keeping (energy etc). Living amenities to the crew like a table, shower, toilets and berths fixed to walls are located in this compartment. Also provided are a moving track and an ergometric bicycle to keep the crew in good physical condition.

The adapter module is attached to the smaller cylinder of the work module and is connected to it through a hatch. This module has one of the two docking assemblies—the second one being in the airlock module—which is used for docking the manned spacecraft. This compartment is also meant for visual observation through seven windows (port-holes) and for carrying out extravehicular activities (EVA or space walk). This compartment therefore is also used as an airlock. The hatch of the docking assembly separating the compartment from the transport spacecraft and the hatch of the work module are closed before egress into outer space. The adapter module contains the space suits used for EVA, control panel, orientation controls and radio communication facilities.

At the other end (rear) of the working module is an unsealed service module. The service module, 4.15m in diameter and 2.2m in length, contains a combined engine system, sensors of the solar panel attitude control system, antennae, lights and mechanism for docking and a TV camera to monitor and control spacecraft/space station docking on the service module side. The combined engine system consists of two vernier jet engines providing a thrust of 300 kg each, 32 control engines providing a thrust of 14 kg each, six propellant tanks with siphon separation of the gas and propellant gas bottles for tank pressurization, pumps for pumping out gas from the tanks during the refuelling process and the pneumo-hydroautomatic equipment. Unsymmetrical dimethylehydrazine (fuel) and nitrogen tetroxide (oxidiser) are used in the engine system as fuel components.

The intermediate module lies along the axis of the service module. One of its ends is welded into the near end of the service module and the entry is through a hatch. At the other end is the second rear docking assembly where both manned transportation and automatic cargo spacecraft may dock. There are two hydroconnectors in the docking assembly through which the combined engine system is refuelled from a cargo spacecraft. The scientific payload module is a cone inserted into the large cylinder of the work module perpendicular to the axis of the station. Its shell is part of the pressurized envelop of the work module. The interior of the cone opens out into outer space. This module contains a major portion of the station's scientific payload.

Salyut-7 is an improved version of the orbital scientific station of the second generation. For example, two of the station's windows are now transparent to ultra-violet light which raises its capabilities for scientific research. It has now become a multipurpose space laboratory. The various instruments installed on the space station can now be supplemented or replaced with the help of the flights of the cargo spacecraft, "Progress". The weight of the scientific payload carried into orbit by the space station is 1500 kgs. The scientific instruments available on board the space station facilitate experiments in material sciences, biology, medicine, astrophysics, meteorology and remote sensing as well as the study of physical properties of space. The station is also more comfortable for the crew to live in and work. Thus the modifications incorporated in the second generation of the space station have expanded the range of possibilities offered by it.

(d) **Mission Control Centre**

The Mission Control Centre in Kaliningrad, about 20 Km from Moscow is one of the most vital components of the infrastructure for a space mission. Housed in a two-storey building, the Centre is entrusted with the exclusive task of keeping a 24-hour vigil on the crew and instructing it on all aspects of the flight navigation as well as on the scientific experiments conducted in space. It has the code name "Light house". It is a word more than 70 cosmonauts of the Soviet Union and 11 other countries have turned to again and again during their arduous journey in space. Sqn. Ldr. Sharma did likewise.

Employed for the task are 2500 men and women who provide ground support for the spacecraft's crew, respond to their pleas and often indulge in a casual banter to give them a feel of "back home". For them, Soyuz-T 11 carrying Sqn. Ldr. Sharma was just "Jupiter" and the space station simply "dawn".

"These are the people who have made it possible", said Mission Information Chief Mr Stephen Bogodiash. "They are the unknown heroes without whom there would be no space flights". The employees from a large number of disciplines seat themselves on the 300 chairs installed in the hall and gather a mass of information flowing in from 2000 computer channels. Among them are 30 specialists who work on the decision making process.

The circular hall is divided into two floors. Working with a computer console each, on the first floor, are the engineers and the specialists analysing the information received from the space station. Commanding them all are the acting chiefs and deputy directors who, also working in shifts, make the final decisions. Stepping in only during important stages of the flight is Mission Director Mr Valery Ryumin.

For the Indo-Soviet mission, the portraits of Sqn. Ldr. Sharma and the other members of the crew as well as flags of India and the Soviet Union adorned the walls of the mission hall.

"It is an excellent system", said Mr Bogodiash, having been successful in guiding every flight since the Centre was set up in 1970. The only failures were in June 1971, August 1974 and April 1979. Mr Bogodiash said these were due to mechanical troubles on board the spaceships.

(e) Packaging Food for Spacemen

Owing to weightlessness, foodstuff in the form in which it is kept on earth behaves differently in space. Normal foodstuff at once starts floating inside the spaceship. Hence special methods have had to be employed for packaging foodstuff intended to be taken into a spaceship.

Bread meant for cosmonauts looks more like a collection of chocolates. This is because if a cosmonaut were to cut bread with a knife, crumbs of bread will spread throughout the spaceship. Cosmonauts never use a knife in a spacecraft. Bread is prepared in the form of small rolls weighing 4.5 grams, the equivalent of a single bite.

To prevent bread from becoming stale too quickly, it is packed in two cellophane wrappers, and special double sterilisation prevents bread from growing mouldy. Initially, three varieties of bread were made for cosmonauts. Now there are six. Meat products are tinned. Some of the foodstuffs in the form of bars are covered with edible film.

Many different anchorages have been designed, as well as special knives for opening tins and tubes. One of the devices called the "bell" prevents splashing about of the contents when the pressure in the tube after heating is higher than the pressure of the surrounding atmosphere. The electric cooker aboard the Salyut makes it possible to heat up food. The remains of food and emptied containers are put into sealed film bags. These bags can be thrown away either through a small air lock chamber or can be stored aboard the "Progress" cargo ship.

The main team of the Joint Indo-Soviet Manned Space Mission from the launch complex at Baikonour Cosmodrome in the Soviet Union.

Photo shows (from left to right) Sqn. Ldr. Rakesh Sharma, Researcher Cosmonaut, Col. Yuri Malyshev, Pilot Cosmonaut and Commander of the Mission and Mr. Genadi Strekalov, Engineer Cosmonaut.

Cosmonauts (R-L) Rakesh Sharma Yuri Malyshev and G. Strekalov prior to the launching.

The alternate crew in readiness: Georgi Grechko, Col. Anatoly Berezovoi and Wing Commander (now Group Captain) Ravish Malhotra, in their space suits.

Genadi Strekelov, Rakesh Sharma and Yuri Malyshev inside Salyut Simulator during training.

VI. Preparations for Countdown

The main and back-up teams for the joint mission left Star City on 23rd March 1984 for Baikonour Space Launch Complex situated on the steppes of the remote Kazhakhistan region. On arrival at the Soviet Cosmodrome, a special bus with isolation equipment for keeping the cosmonauts free from any infection, carried them to the hotel.

On 1st April 1984 the Soyuz Spacecraft was perched atop a launcher 50 metres high at the launch pad and the final count down began for it to soar toward Salyut station bearing the Indian cosmonaut and his Soviet colleagues. The Indian and Soviet national flags flew at the observation platform and the banner at the entrance to the cosmodrome wished success both in Russian and Hindi to the Indian cosmonaut. Banners displaying in Hindi "Antariksh Ke Bharatiya Vijetaon Ko Namaskar" (Greetings to the Indian conqueror of space) had been put up over the Baikonour spacecraft assembly and testing building, where Sqn. Ldr. Rakesh Sharma donned the space suite, as well as at the entrance to the Complex itself.

The Soyuz T 11 was brought out of the semi-underground assembly and test building shortly after 7.30 in the morning of the 1st April by a special transporter erector and taken along with the awesome 16 storey high booster rocket to the launch pad. It was positioned on the pad and connected to the complex's Control Command Centre in less than an hour. The testing of all systems for the final round commenced and the telemetred data started flowing to the computers of the Control Command Centre. The fuelling circuit was also connected to the spacecraft launcher assembly but the fuelling was done only a few hours before the actual launch. The fuel mixture of liquid oxygen and kerosene lay on a railway tanker to the left of the assembly. A train of fuel tankers were on the siding to the right to fill the underground tanks on 2nd April. Two service columns to the right and left of the assembly were also in position to provide access to the spacecraft for the cosmonauts, as well as for servicing and technical personnel engaged in the final stage of testing and launch preparations.

All systems were given a final check on 3rd April before the cosmonauts arrived at a specially equipped room in the assembly and test complex to undergo the last medical check-up, after which they put on their pressure suits and headed for the rocket. Then began the two-and-a-half hour readiness countdown. Meanwhile, preparations had been completed aboard the orbiting laboratory Salyut-7 for studies under the programme of the joint mission.

The Mission Information Centre (MIC) at the Air Headquarters in Delhi was formally opened on 30th March by the Chief of Air Staff, Air Chief Marshal Dilbagh Singh. It served as the nodal point of all communications with the Mission Control Centre (MCC) in Kaliningrad, 30 km from Moscow during the mission. Dr Militsen, Chief of the MCC, told the Indian Chief of Air Staff on the hotline: "We are certain that this joint flight will further

cement the bonds between our two countries and will add to increased co-operation and greater understanding in future".

The Mission Information Centre in Delhi maintained upto date information on the progress of the mission, issued periodical news bulletins, held press conferences and co-ordinated all activities relating to the conduct of experiments during the mission. The MCC had two sections—the control room and the TV studio-cum-press briefing room. The control room was directly linked with Kaliningrad through direct voice and teletype communication channels. There were two hot lines, (direct telephone communication facilities) and a teletype facility between MCC and MIC The communication links were established via the Intelsat satellite by the Overseas Communications Service of India.

In addition, the MIC had two computer-based information display systems, one of which, called the Events Calender, displayed events scheduled for the day. The indicator also displayed in yellow, green and red dots the next, present and previous orbits of the Salyut station which was shown as a pink square on the green line. The MIC also received from space daily telecasts in which the Indian cosmonaut spoke on various aspects of the mission. These were fed to Doordarshan for telecast on the national look-up.

Elaborate arrangements were made both in India and the Soviet Union to bring the excitement of space travel to the people. The blast-off was telecast "live" on Doordarshan's national network. The Prime Minister's talk with the Indian cosmonaut on the evening of 5th April as well as other memorable events like docking, undocking and landing back on earth were all broadcast live.

The spacemen had emblazoned on their pearly white space suits with sea blue linings, the mission emblem *Surya*, depicting the Sun as an old man with a dark red face and three eyes, riding a golden chariot drawn by seven horses into the sky. The mission emblem was one of the badges which all crew members of the joint space flight wore on their space suits and work clothing. The other badges worn by Sqn. Ldr. Sharma during the mission were: (a) The Indian National Tricolour, (b) The Air Force Badge, as the Organisation badge, also showing the different Indian Organisations taking part in the joint mission, and (c) the National Emblem—the Ashoka lions.

Sqn. Ldr. Sharma carried with him 'a piece of India'—a bit of soil from Rajghat where Mahatma Gandhi was cremated. He also carried photographs of Mahatma Gandhi, Jawaharlal Nehru, President Zail Singh, the late Prime Minister Mrs Indira Gandhi, and the then Defence Minister Mr. R. Venkatraman as well as the following for stamping on board Salyut-7:

i) Emblems of Indian Research Organizations which sponsored in flight experiments.
ii) First day postal covers and franking (cancellation stamp) equipment.
iii) National flags of India & USSR.

After he brought them back, they were to be placed in the National Museum as mementoes.

VII. The Blast off and After

(a) **The Blast-off**

At 6.30 p.m. on 3rd April, Sqn. Ldr. Sharma became India's first man in space when he was launched aboard Soyuz-T-11 spaceship from Baikonour cosmodrome, the largest in the Soviet Union, along with two Soviet cosmonauts. India thus reached out for new frontiers of knowledge 23 years to the month after the Soviet Union had done so. It was in April 1961 that Col. Yuri Gagarin of the Soviet Union made the first ever journey in space. On his visit to India later that year, Yuri Gagarin had said: "I have no doubt that a day would come when the family of cosmonauts is joined by a citizen of the Republic of India."

A 300-tonne three-stage rocket carrying the Soyuz in its nose cone, flashed into life, when its propellants made of a mixture of oxygen and kerosene were ignited by an electrical impulse sent by a computer in the cosmodrome. Within a few seconds the rocket disappeared into the blue sky leaving a trail of white smoke behind. The final minutes before the take-off were filled with tense drama. The towering rocket with the green and white spacecraft on its nose stood glistening in the afternoon sun under an azure sky. While the countdown was nearing the finale, Sqn. Ldr. Sharma, Commander Malyshev and cosmonaut Genadi Strekalov arrived at the foot of the booster. The three cosmonauts moved into the space vehicle where they were shown on TV reclining and huddled together. They exchanged messages with ground control where Wg. Cdr. Ravish Malhotra and the two Soviet cosmonauts in the back-up team were discussing the flight details. Just before the launch, cosmonauts Malyshev and Sharma read out messages to their nations in Russian and Hindi respectively.

Earlier, wearing white space suits and carrying their portable crew ventilating system the cosmonauts arrived in a bus at the launching pad about two-and-a-half hours before the blast-off. After Commander Yuri Malyshev reported to the Chairman of the Space Commission and sought his permission for the flight, the three cosmonauts entered the space vehicle. The final countdown began precisely 10 seconds before the launch.

The lift-off was an awesome spectacle as the rocket streaked into the azure sky with its tail of flame filling the place with crimson glow and the deep rumble shaking the earth for miles around. Sqn. Ldr. Sharma crouched inside the module of Soyuz-T-11, struggled against the tremendous pull of the earth's gravity. But the discomfort did not last long as the Soyuz launch vehicle was moving away from the Earth at a mean speed of four kilometres a second and within the first five minutes it had climbed 160 Km. Nine minutes after the blast-off, at a height of 200 Km above the earth, Soyuz-T-11 was hurled into space at nearly eight kilometres a second and Sqn. Ldr. Sharma was liberated from the pull of gravity.

Rakesh Sharma's wife, Madhu and nine year old son Kapil were watching the spectacle on television in an apartment complex in Star City. "I am shaken up but very happy. Everything

went smoothly", she said adding: "I could never believe it. It was something wonderful." Thousands of miles away in Hyderabad, Sharma's parents watched it too on their television set. Earlier in the morning they offered prayers at the Hanuman Temple and performed "Akhand path" at a gurudwara for the safe and successful completion of their son's space odyssey. Before the launch, Sharma had spoken on telephone to his mother in Hyderabad and also to other members of his family and assured them: "Don't worry, everything is fine. I am confident." His mother Mrs. Tripta Sharma reciprocated: "Congratulations, we are confident you can come out from the mission successfully. God bless you."

Asked by correspondents about his feelings on the flight, Sqn. Ldr. Sharma said: "It had been my cherished dream to undertake a space voyage; today it is being realised. With the launching of our spacecraft, a new stage in Indo-Soviet cooperation commences". Replying to the same question, the commander Col. Yuri Malyshev expressed happiness, satisfaction and confidence. He also disclosed that on the 13th to 14th rotation around the earth, the cosmonauts would briefly see India. He said: "It will be a brief observation just to watch whether clouds are there or not and such other things, since the most delicate phase of our journey will be lyind ahead".

Just before lift-off, Sqn. Ldr. Sharma said that it was a special honour to be the first representative of India in this challenging endeavour and "to make a modest contribution to the mastering of new frontiers of human knowledge." Opening his statement with the traditional Soviet "Dear comrades and friends", Sqn. Ldr. Sharma said: "It is a great honour for a citizen of the Republic of India to be a member of the international crew of the ship Soyuz-T-11 in the joint manned space flight and to have the possibility to conduct scientific experiments on board the space station Salyut-7".

The Indian cosmonaut added that he was aware that this event had become possible owing to the efforts of many people in India and the Soviet Union. Expressing gratitude to all those who had helped to make this historic event possible, Sqn. Ldr. Sharma dedicated the flight to all those "who have faith in me and entrusted the mission to me and to the eternal friendship between the great peoples of India and the Soviet Union".

The Soyuz commander, Yuri Malyshev, in his statement just before the blast-off hailed the flight as a new major step along the road of continuously developing cooperation between India and the Soviet Union in the field of peaceful studies in space.

Mr. Kotelnikov, Chairman of Intercosmos said that the fulfilment of the Cosmos flight would enable India to train its own cosmonauts, make use of complex data obtained from its manned and unmanned spacecraft which the country would use in developing its economy and science and technology. He recalled that Intercosmos and the Indian Space Research Organisation had signed their first agreement as long ago as 1972 but during this period India could launch three satellites from the Soviet cosmodrome. It had established its own space production and technical base for space objects, tracking stations, ground control stations and centres for receiving telemetric information. Mr. Kotelnikov laid special emphasis on the Indian success in building its own cadre of space specialists, scientists and experts, who he said were capable of solving complex problems in the field of space techniques.

The space team received messages of good wishes from President Zail Singh of India, the

late Prime Minister Mrs. Indira Gandhi and the late President Konstantin Chernenko of the Soviet Union. In an interview to the correspondent of the Soviet news agency **Tass,** Mrs. Gandhi said that the people of India were thrilled that an Indian was going into space along with Soviet cosmonauts. "It is a proud occasion for us. This is being made possible by Soviet-Indian friendship, which now acquires a new dimension", she said.

Stressing the need on the peaceful use of space science, Mrs. Gandhi said: "The space above us must be peaceful as the land and ocean around us. It must hold no terror for any nation". She hoped that India's first cosmonaut, Sqn. Ldr. Sharma would symoblise the message of peace "which is Mahatma Gandhi's and Jawaharlal Nehru's legacy to India". "Knowledge must be for the growth and enrichment of the spirit and never for destruction", she said. Mrs. Gandhi had a telephonic talk with India's ambassador to the Soviet Union, Prof. Nurul Hassan, soon after the Soyuz-T-11 was put into orbit. "Cordial thanks to all who have built another bridge of friendship between our two countries", Mrs. Gandhi was quoted by **Tass** as having told Prof. Hassan.

Millions of people in India watched the launching, telecast 'live'. In New Delhi, Members of Parliament formed a Space Club on the day of the launching to provide special information on space matters and help spread knowledge about space.

(b) **Docking With Salyut-7**

The most crucial stage of the mission, the docking with Salyut-7 lay ahead. Soyuz-T-11 was orbiting the earth once every 88.6 minutes at an apogee of 238 Km and a perigee of 202 Km. It had to draw level with Salyut-7 at an altitude of 300 Km before docking. During the first orbit, the crew checked radio equipment and pressurisation. During the second they tested the on-board computer, switched on the manual mode and found it working "very well". Checking of all on-board systems having been completed in the first two orbits, the crew took off their space suits during the third and had their meals. "They are in high spirits", the experts said. The cosmonauts' pulse rate and breathing during the third orbit was normal—almost like on earth. Travelling at an average speed of 8 Km per second, the spacecraft was taking 89.4 minutes for one orbit, against 88.63 minutes immediately after the blast off.

During the fourth and fifth orbits, the Mission Control Centre at Kaliningrad carried out a manoeuvre which raised the orbit of Soyuz-T-11 putting it in the path of Salyut-7, some 7000 km away. During the period between the sixth and 11th orbits, the crew slept, and between the 11th and 12th orbits, a remote control approach was made and then the crew prepared the spacecraft for docking with the Salyut Space Station. During the 17th orbit, the cosmonauts carried out a manoeuvre which enabled the spacecraft to close in on the Space Station until it was near enough to make an automatic approach using autonomous pointing equipment. This manoeuvre in the "suspension" flight regime was carried out when both spacecraft and space station were 200 to 400 m apart. After checking the space station systems, the crew on orders from the ground initiated the docking process. Junction and docking of the spacecraft with the space station took place during the 18th orbit in the radio visibility zone of the tracking stations situated in Soviet territory.

Commander Malyshev kept his hands on the manual system although the flight and other processes were automatically controlled. The computer system was continuously receiving all the data from the various systems on board the Soyuz and Salyut and passing them on to the commander after processing. The Soyuz crew had been chasing the orbital station for 18 hours, steadily decreasing the distance between the two spacecraft that was 8000 Km at the time of the launch. The Soyuz finally approached the Salyut at a speed of three centimetres a second for the mechanical docking. As the two vehicles docked at 22 seconds past 8.01 pm (IST) on 4th April, the crew felt a little jerk, normal in all such link-ups.

In the meantime, the space station had already received the equipment for scientific experiments from the Cargo spacecraft "Progress". This spacecraft had earlier docked to Salyut after which the host crew in orbit had transferred the equipment and installed it in Salyut. Thereafter, the Progress vehicle was jettisoned to make way for Soyuz T-11 spacecraft.

After docking, the Soyuz-T-11 crew spent two hours and six minutes checking the electrical system of their spacecraft and made sure the link was sealed before opening the hatch and making their dramatic entry. At 11.07 pm (IST) the tunnel connecting the spacecraft and the space station opened and Sqn. Ldr. Sharma, floated into Salyut-7 followed by Commander Yuri Malyshev and Flight Engineer Genadi Strekalov for a warm welcome by their hosts- Commander Leonid Kizim, Vladimir Solovyov and Dr Oleg Atkov. Commander Kizim thenceforth assumed leadership of the full complement. This was the first time that as many as six people were aboard an orbiting Soviet spacecraft. Within 20 minutes of arrival aboard, Sqn. Ldr. Sharma had a look at his motherland as the orbital complex made a six minute pass over the Indian sub-continent.

"I am elated", said Wg. Cdr. Ravish Malhotra as the Soyuz T-11 docked with Salyut 7. "Everything is bang on", he said at the Mission Control Centre, Kaliningrad. "Right now all systems are go", he said immediately after the Soyuz established contact with Salyut-7.

Madhu, wife of Sqn. Ldr. Sharma, said: "If there is anything like being on top of the world, this is it. I am much more delighted than I was yesterday and am awaiting the next thrill, that of landing". At the ground station, there were cheers and applause when the three entered the spaceship. Watching the manoeuvre was Prof Nurul Hassan. All six spacemen had a celebration dinner before going to sleep. The docking was shown live by Soviet and Indian television. The cosomonauts' entry into Salyut 7 was delayed by one orbit in order that it was made over the Soviet Union in radio visibility of the ground tracking stations and televised.

On the successful docking of Soyuz T-11 spacecraft with Salyut-7 space station, the President Mr Zail Singh, and Mrs Gandhi felicitated the Indian and Soviet cosmonauts. In messages of greetings, they expressed the hope that their joint efforts would contribute to the advancement of science. Both wished the cosmonauts a safe journey and successful completion of the important tasks assigned to them. Mr Zail Singh said this was an outstanding example of how the countries could work together constructively for the mutual benefit and for the good of mankind.

Mrs Gandhi said: "For India, this is indeed a historic moment."

The President said: "I have great pleasure in extending my warm felicitations and

greetings to the Soviet and Indian friends participating in the joint space venture. Our thanks are due to the several citizens of our two countries who have worked hard to bring this about."

"I am particularly happy that for the first time an Indian cosmonaut will be going into space. Your mission is a symbol of Indo-Soviet friendship and an outstanding example of how two countries can work together constructively for the advancement of science, for mutual benefit and for the good of mankind."

"I would like to wish you the very best for successful completion of the important tasks assigned to you."

Mrs Gandhi said: "The Government and the entire people of India join me in sending you felicitations and good wishes on your mission into space. Months of intensive planning and efforts have thus been brought to a successful take-off."

"Our thanks are due to the many Soviet and Indian citizens who worked together to make this possible. For India, this is indeed a historic moment."

"This venture is an important event in the history of relations between our two countries. It is yet another oustanding example of the constructive cooperation for the good of our two peoples which our friendship has always fostered. Your joint efforts will contribute to the advancement of science."

"Our thoughts are with you as you go into space. I wish you a safe journey and the very best in the successful fulfilment of the responsibilities entrusted to you".

The Lok Sabha on 4th April praised the launching of the first Indian in space aboard a Soviet Soyuz spacecraft and conveyed its greetings to Sqn. Ldr. Rakesh Sharma and his Russian fellow cosmonauts.

Mrs Gandhi was joined by the House in expressing pride over the feat.

Describing the launching of an Indian in space as a "great achievement", Mrs Gandhi said that the space flight, though risky, was a new experience for India.

The Prime Minister also sent good wishes to the others, specially Wg. Cdr. Ravish Malhotra who had also gone through a difficult training programme.

Mrs Gandhi said the people's thoughts were with the families of the young men to whom they sent their good wishes.

(c) A Talk Across Space

On his second day in space, Sqn. Ldr. Rakesh Sharma had the excitement of talking to the late Prime Minister, Mrs Indira Gandhi, across space. She spoke to him from the Mission Information Centre at the Air Headquarters in New Delhi for 10 minutes and the historic conversation was telecast and broadcast live over India's network. But due to certain technical problems, while the viewers were able to see both Mrs Gandhi and the cosmonauts on their TV screens, the cosmonauts themselves were not able to see Mrs Gandhi actually talking to them but could only hear her voice.

The relay of the unique 10-minute conversation involved complex technical arrangements. The pictures of Mrs Gandhi and Sqn. Ldr. Sharma were very clear, marking a new phase in the use of space technology in the country. Elaborate arrangements were made for bringing the video and voice beams from the spaceship to the TV Centre for telecast on the national hook-up. The spaceship was tracked through several tracking stations in the Soviet Union and the video and speech signals were transmitted to Delhi through the satellite stations. The signals were received by the Posts and Telegraphs' earth station at Sikandrabad in Uttar Pradesh and transmitted to the TV Centre, Delhi on the microwave and coaxial cable links. After processing, the video and speech signals were telecast live flawlessly to the national television network.

Soviet television and all stations of Moscow Radio suspended their programmes and presented to their viewers and listeners the conversation between Mrs Gandhi and Sqn. Ldr. Sharma. The Soviet TV presented the programme in its special telecast "Intervision" which, as a rule, is used exclusively for major official announcements and events of major importance in Soviet life. There had been no prior announcement for it. This was an international hook-up in the socialist block and the interview was thus seen simultaneously throughout the Soviet Union, Rumania, Hungary, Poland, Czechoslovakia, the Mongolian People's Republic, Vietnam and North Korea. The Soviet TV gave an important place to the joint space mission in all their telecasts despite the fact that the Supreme Soviet was scheduled to meet on the 11th April for which large scale preparations were going on. It was the Supreme Soviet's first meeting after Mr Andropov's death.

During the conversation, Mrs Ganndhi hoped that the "historic endeavour" of Sqn. Ldr. Rakesh Sharma in space would inspire India's youth to be more adventurous and the country space conscious. India desires to use the knowledge gained from the mysteries of outer space for the good of the whole of mankind, she said, in her introductory remarks in English after a five minute chat with Sqn. Ldr. Sharma in Hindi. The joint manned flight, she said, was a unique example of Indo-Soviet cooperation. She wished him and his Soviet cosmonauts aboard Salyut-7 a safe journey and joyous return to earth. The entire nation, Mrs Gandhi told Sqn. Ldr. Sharma, was "focussed on you".

Asked by the Prime Minister how he felt in the spacecraft, he replied it was just like sitting in a simulator during training.

"How does India look from above?" she asked.

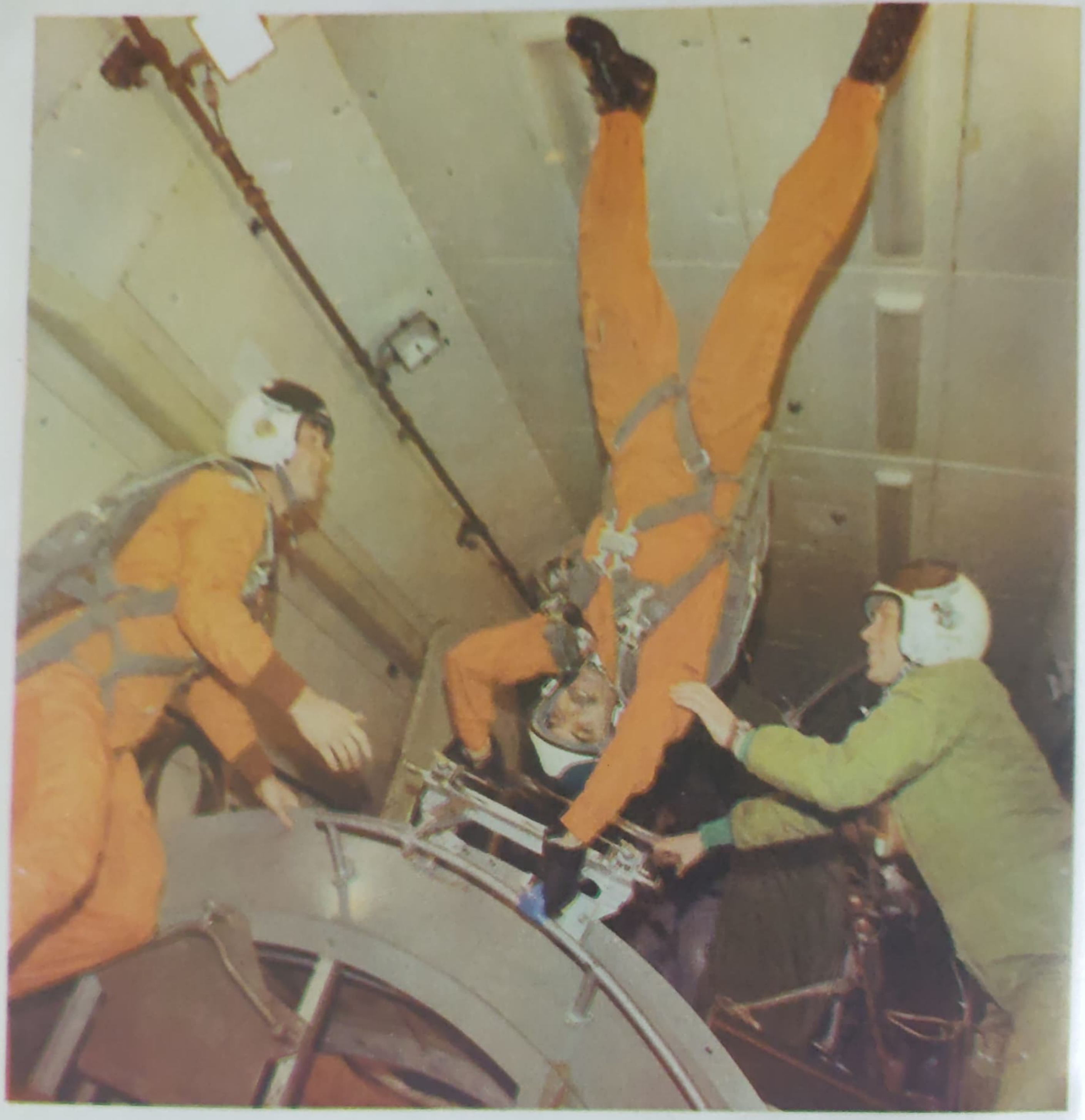
"Sare jahan se acha" (the best in the entire world), was the reply.

"Out health is very good and we are eating more than the required quantities", Sqn. Ldr. Sharma informed Mrs Gandhi. They were having piping hot food prepared by the Soviet crew of Salyut space station.

Extending greetings to all the cosmonauts, Mrs Gandhi said the experiments being carried out in outer space would be used for peaceful purposes and the betterment of manking.

Mrs. Gandhi assured the cosmonauts: "Our hearts are with you for a successful journey, and safe landing. We are eagerly looking forward to Rakesh Sharma's return to India." The people of India, she said wanted to see all the cosmonauts face to face, she informed them.

It takes a man of sterner stuff to be a cosmonaut. Picture shows Ravish and Rakesh afer a bout of skiing.



Ravish Malhotra is not practising yoga but simulating weightlessness.

Rakesh Sharma – Training in splashdown at Black Sea.

A real friend indeed! Rakesh Sharma preparing Yuri Malyshev for optokinesis experiments while under training.

The dream come true! The blast-off of Soyuz T-11

Though Mrs Gandhi was addressing Sqn. Ldr. Sharma for the greater part of the 10-minute conversation, the entire Soviet crew was seen listening to her intently.

She was glad to hear that the space crew was feeling well, mentally and physically.

Mrs Gandhi had equal admiration for the hard work put in by Wg. Cdr. Ravish Malhotra as a member of the back-up crew who had been a "good companion to you during the arduous months of preparation."

Earlier talking to the Defence Minister, Mr R. Venkatraman, Sqn. Ldr. Sharma said the sight of the Earth from space made him confident that "all is going well with the world".

Mr. Venkatraman had asked him if the sight of the Earth from far off made him feel strange or different.

"No, no sir", he replied. "To see the Earth going round builds up my confidence that all is going well with the world, I saw it yesterday and it looked beautiful. I saw the entire earth, cloud free and saw the country change over from deep blue to brown landmarks and then the green of the northeast."

Mr Venkatraman's talk with Sqn. Ldr. Sharma was in fact a trial run to check the space station's satellite communication with New Delhi for Mrs. Gandhi's talk.

Sqn. Ldr. Sharma said all systems were "working perfectly" and hoped they would continue to do so "till we are here."

Asked how he felt on docking, he said: "No problem. When we reached, the host crew had the table laid out for us and we had dinner with them."

He gave the Defence Minister a brief report of his activities during the day.

In a conversation with Air Chief Marshal Dilbagh Singh, he said: "For the Indian Air Force the sky is no longer the limit."

The Air Chief Marshall told him that the Indian Air Force was "very proud" of his achievement.

Sqn. Ldr. Sharma said he was equally proud of the country and the Air Force. "I am really looking forward to be back among you all once again." he said.

Air Chief Marshall Dilbagh Singh asked him to convey his greetings to the other "brave men" aboard the space complex.

The conversation over, Sqn. Ldr. Sharma gave the message to his fellow cosmonauts, bringing smiles on their faces.

In a space-earth teletalk again on 8th April, Sqn. Ldr. Sharma said, "It's not twinkle twinkle little star from up here". The cosmonaut said that he could clearly see the stars and planets as small lights though the stars did not seem to twinkle. The interview was carried by Delhi TV from the Mission Control Centre near Moscow and was telecast live. Asked how he passed his time when there was no work, Sqn. Ldr. Sharma replied: "I just peep through the window and watch the timeless space".

Question: Don't you feel a tiny human being up there, dwarfed by the endless space?

Sqn. Ldr. Sharma: Certainly, it's mind boggling.
Question: Do you sweat?
Sqn. Ldr. Sharma: Yes, I do, after physical exercises, just as anyone would on earth.
Question (amidst laughter): How about prospects of an encounter with extra-terrestrial beings?
Sqn. Ldr. Sharma (amidst laughter): I would love to have such an experience.

The Commander of Salyut space station was asked as to how he rated Sqn. Ldr. Sharma. The reply was: "Sharma has shown a very high standard of professionalism and he is a very fine human being".

The Indian cosmonaut said that he was not feeling home-sick and talked to his family regularly. To another question, the cosmonaut said that he would have liked to stay in space longer but his visit was time-bound and would have to return to earth as scheduled.

Television viewers had a panoramic view of the earth when Sqn. Ldr. Sharma, focussed his camera on the planet from the orbiting spaceship. The earth in a live telecast, looked magnificient in various hues. He showed his countrymen the various equipment used by him in remote sensing experiments.

(d) **A Week in Space**

Salyut 7 was orbiting in space for six more days with the six men aboard until the Soyuz-T-10 vehicle was undocked, and later, on 11th April, touched down softly on the marshy plains of the town of Arkalyk, 600 km from the cosmodrome. These six days were cramped with scientific experiments of a varied nature for the crewmen.

On his second day aboard the orbiting space laboratory, Sqn. Ldr. Sharma, wearing a special belt to help prevent the blood rushing to the upper part of the body, conducted a series of bio-medical experiments. While his three experiments were of a varied nature, cosmonaut Yuri Malyshev conducted two experiments on "prophylactics" which sought to prevent vestibular disorder, a problem which plagues cosmonauts in conditions of weightlessness. All the three visiting cosmonauts had a "feeling of fullness" in the nose, considered inevitable in conditions of weightlessness. The stuffiness which results during initial adaptation periods, disappeared the following day as the cosmonauts tied cuffs on their thigh muscles and bracelets on the wrists to reduce blood flow to the upper body.

Sqn. Ldr. Sharma's first experiment was on "optokinesis", an as yet unexplained ailment that strikes cosmonauts with vomiting and giddiness in their first few days. The experiment was performed by taking blood samples of Soviet crew members immediately after breakfast between 1.40 pm and 2.40 pm (IST).

From 5.30 pm to 6.30 pm Sqn. Ldr. Sharma did his Yoga experiments as Yuri Malyshev had another go at "prophylactics". The cosmonauts also transferred the assembly and individual gear from Soyuz T-11 following a decision taken at ground control that the new crew would leave aboard the spacecraft of the host crew, Soyuz T-10.

Two hours after his talk with Mrs Gandhi, Sqn. Ldr. Sharma took part in the joint questionnaire experiment under which the crew had to fill out identical sets of questions.

Salyut-7 passed over India four times in a 24-hour cycle—two passes by day and two by night. The Spacemen were in top physical condition so much so that the doctor on board, Dr Oleg Atkov, said: "I have no patients".

....

The Indian sponsored "Terra" remote sensing experiment was started on 6th April. Indian territory was photographed during several passes over the country. Salyut-7 made four orbits over India on 6th April, two of them during the night. The cosmonauts filmed with wide angle multi-spectral cameras for four minutes and 20 seconds, the areas of the Andaman and Nicobar as well as the Lakshadweep islands, and the north-western areas and the eastern coast line. They also took photographs of the Ganga, the flood-prone areas of the west coast and during its last trajectory, the spacecraft flew over Mt Everest where there was at that time an Indian expedition. Space officials said that very significant results were obtained by the crew which took 230 shots with hand-held camera operated by Sqn. Ldr. Sharma. Twenty per cent of the Indian land Mass and adjacent areas were photographed during the first three sessions of the "Terra" experiment which began on 6th April.

Each overflight lasted two to 10 minutes. While the skies over the Andaman islands were almost clear, there were some meteorological problems during the next two passes. It was pointed out that 90 per cent of the forest of Andaman and Nicobar Islands and the region between the Western Ghats and river Narmada were covered in the photographic experiment. Though cloudy, the cosmonauts took pictures of the ice caps of the Himalayas. The "Terra" earth observation continued until 10th April. Though Salyut overflew India 15 times during the joint flight, pictures were taken during a total of seven passes.

The pictures of Indian territory would help identify structures holding out the promise of oil, gas and other natural resources. Besides, they would be used for remote sensing in the fields of geology, land use, environment, snow cover, hydrology and agriculture. Photographs made in one orbit were expected to yield information equivalent to aerial surveys of two years. Sqn. Ldr. Sharma participated in four of nine experiments conducted on 6th April. They were "Ballisto-3", "Vector", "Questionnaire" and "Yoga".

On 7th April, the crew began preparing for experiment on the silver-germanium alloys which Sqn. Ldr. Sharma said might help in developing "something which can never be achieved on earth". The experiment used a new method developed by Indian scientists, to undercool the alloys in space, which could lead to the development of new alloys impossible to create under conditions of gravity on earth. On 8th April the "evaporator" equipment used for conducting the experiments with the silver-germanium alloy was slightly "off the norm", but the Salyut crew working with experts on ground successfully commissioned it the next day and carried out two experiments with two samples of silver-germanium alloy. The alloys prepared in space by "undercooling" were left outside the spacecraft to expose them to the vacuum of space. But the nagging problem with the equipment cropped up once again on 9th April. The trouble with the Soviet made "evaporator" equipment was stated to be "inexplicable temperature changes" in a number of micro-chips in the equipment. "The experiment is stalled", Dr Ramachandra Rao, member of the Indian technical team in Kaliningrad, told newsmen at the Mission Control Centre. However, he added, work on the "most critical" part of the experiment had already been done. Dr Rao said that a large number of specialists at the ground control were busy trying to rectify the problem but even

if the malfunction went unrectified it would not have made much difference to the equipment. The "evaporator" had been brought to the space station in February with the Soyuz T-10 crew, but had been tested a week before the arrival of the Indo-Soviet crew. Sqn. Ldr. Sharma in his report on 9th April sounded a futuristic note when he said that experiments with the silver-germanium alloys might one day make possible the production of "cost-effective material for day to day use on earth".

On 8th April, the crew in one orbit photographed areas starting with south of Sri Lanka to the Indo-Burma borders and in the other took pictures of the western part of India-from the Arabian sea to the Gulf of Cambay to parts of Gujarat and Chambal Valley and mountain peaks of Kailash and Nanda Devi. Officials said that the three cameras aboard the space station had taken by then 937 frames, and by the end of the "Terra" experiment, they expected to cover 40 per cent of the Indian territory.

The crew on its fifth working day in space conducted 10 experiments- one on Yoga, three with the India-developed vector cardiogram, three on blood circulation, and three on remote sensing during which the craft overflew eastern and western coasts of India. 9th April was the last day of the experiments except for continuation of the "Terra" experiment on 10th April as no pictures could be taken the previous day over the east coast of India due to cloudy skies. The crew devoted most of its time on 10th April to checking and testing the engines of Soyuz-spacecraft which was to bring the team back to earth.

(e) **Sqn. Ldr. Sharma's Routine In space**

A man in space has perforce to observe a strict regimen. Months of training had familiarised Sqn. Ldr. Sharma with conditions in space and he was thorough with what he was expected to do every hour of the day in space. Fifteen hours of the 24 were in carrying out various chores, the remaining nine hours being allowed for sleep. In a space ship, the cosmonauts are strapped to sleeping bags while sleeping since in the absence of gravity, everything, including water, flies around. After the alloted hours of sleep, an alarm bell rings persistently to wake up the cosmonauts. They are allowed an hour for wash and breakfast. Salyut's toilets are fitted with special showers and commodes so that water and waste material do not fly around.

For the first time, some items of Indian food were taken into space. The food was shared by all the cosmonauts. The items included mango and pinapple juice, and mango bars and banana crisps.

For 20 minutes everyday, Sqn. Ldr. Sharma performed Yoga exercises-two minutes each of five yoga **asanas,** the **Sithlikarna, Vyama Pada Hastasana, Parivarta, Trikon asana Ustrasana** and **Pranayama**. The ten minutes profile was repeated. These yogic exercises were selected by Sqn. Ldr. J.M. Wadhawan, an expert of the Institute of Aviation Medicine, who paid visits to the Soviet Union twice to train Sqn. Ldr. Sharma, and Wg. Cdr. Malhotra. The Soviet cosmonauts did cycling exercises.

For two hours everyday, Sqn. Ldr. Sharma was subjected to tests on the effect of zero gravity on the functioning of his heart, with electrodes fitted on his chest, neck and thighs. He spent the rest of the time photographying Indian territory and carrying out various

experiments entrusted to him, including "Terra", "undercooling" and so on. Everyday, while in space, for ten minutes, Sqn. Ldr. Sharma enthralled Indian TV audiences with demonstrations of how he lived and worked in the space station. He showed them the various equipment he used and demonstrated how things flew inside the station.

(f) Soyuz Touchdown

At 4.19 pm (IST) on 11th April, India's first cosmonaut Sqn. Ldr. Sharma safely returned from his maiden space voyage landing on a carpet of fresh snow in Kazhakhistan, near the town of Arkalik. The Soyuz T-10 landing module carrying Sqn. Ldr. Sharma and his two Soviet colleagues touched down four and a half hours after they detached from Salyut-7.

The crew began their return journey to Earth on the morning of the 11th April.

The host crew led by Mr Leonid Kizim made their guests, the three "Jupiters", as Sqn. Ldr. Sharma, Yuri Malyshev and Genadi Strekalov were collectively called, to sit down with them for a few minutes in silent meditation, in accordance with the Russian tradition, before the departure. The farewell was an emotional affair as the six hugged each other. Sqn. Ldr. Sharma then floated into the transfer hatch first and was followed by Strekalov and Malyshev. Each smiled and waved before their heads disappeared into the transfer hatch. They had carried away the previous night the precious silver-germanium alloy bars, the films of the space photography of almost half of Indian territory and magnetic tapes of the data on medical experiments, including yoga, conducted to overcome space sickness. They brought back mementos they took up like portraits of national leaders, the Indian and Soviet national flags, first day postal covers franked in space and a bit of India, the sacred soil picked up from the Gandhi Samadhi at Rajghat. They also carried back the results of the experiments the Salyut-7 crew conducted between 9th February and the arrival of the "guests" on 4th April.

Soyuz-T-10 separated from Salyut-7 at 1.02 pm (IST). Sqn. Ldr. Sharma and his crew—mates sent back to Mission Control minutes later a televised picture of Salyut-7 majestic with its three solar panels moving on in its orbit while their own spacecraft distanced itself at the rate of 43 cm per second before lowering into a separate orbit of its own.

After the jettisoning of the living or transfer module, the retarding engines were fired at 3.33 pm, reducing the speed of the spacecraft to below the orbital speed of 8 km an hour. The spacecraft stopped orbiting and began the descent 202 seconds later at 3.36.22 pm. The equipment module was jettisoned at 3.53.30 pm and the descent module entered the atmosphere with its outer protective layer turning a fiery red with the temperature rising to 2500 degrees centigrade, Inside the module, however, the temperature was a cool 20 degrees. The descent module which entered the atmosphere at a speed of 7.2 km per second, was slowed down to approximately 300 m per second a height of 10 km, when the main parachute opened automatically. This was sighted immediately by a land vehicle and reported to the Mission Control Centre. Seconds later, helicopters received the "beep" of the radio signals from the descent module and followed the "beep" toward the landing site. The leading helicopter quickly established radio contact with the crew inside the descent module and was able to flash the report to the mission control that the Indian cosmonaut

and his Soviet collegeus were feeling fine. Several helicopters were now converging on the landing site. A telemetric check now showed that all systems were ready for the touchdown. At just 20 metres from ground, four retro-rockets burst into life placing the module gently on the ground. The touchdown took place at 4.19.16 pm and the module became completely immobile. The entire descent was controlled by on board computer. Pushed by heavy winds, the module landed on its edge slightly tilted to the left.

Sqn. Ldr. Sharma and his colleagues radioed even before the hatch was opened that they were in excellent condition and spirits. Ten planes and 15 helicopters and numerous land vehicles were deployed on the recovery and rescue mission.

The first to emerge from the capsule was Col. Yuri Malyshev. Ten minutes later the rescue team brought up the Indian cosmonaut looking tired but cheerful. The last to emerge was cosmonaut Strekalov.

"I am feeling three times heavier now," said the Indian cosmonaut who had for the first time spent eight days in the weightlessness of space.

Seconds after landing, Rakesh's colleagues and stand-by cosmonaut Wg. Cdr. Ravish Malhotra peeped through the glass port.

"I could not speak to him but confirmed he was safe and well," he said.

The equipment and other materials brought back by the cosmonauts were first evacuated from the module before the trio were freed from the chamber. The entire operation took about 30 minutes.

The cosmonauts, who were tired, were lifted through the hatch and put on chairs just near the space capsule. They were wearing their spacesuits as they came out of the capsule.

Most pleased to see Rakesh was Wg. Cdr. Malhotra, who rushed toward his friend for a warm embrace and a kiss on the cheek.

"I am happy you are safe and back", Malhotra told Rakesh. The crowd of newsmen, officials, and onlookers broke into applause as Wg. Cdr. Malhotra put garlands around the cosmonauts' necks.

Wg. Cdr. Malhotra told newsmen: "It is wonderful to see them back. It is all over, but is just beginning."

The cosmonauts posed before cameramen and talked with newsmen for about 15 minutes before being whisked off in an ambulance to a temporary enclosure nearby, for medical examination.

Sq. Ldr. Sharma said there were no problems during descent except that he had to get used to gravity again. "I am feeling three times heavier now".

Asked what he achieved in space, he quipped, "I am back home. That in itself is an achievement." He said the scientific studies were a total success.

Before being taken to medical tests, the crew wrote their names on the charred face of the descent module below the caption that said: "Spaceship of Indo-Soviet friendship."

The cosmonauts after preliminary check-up were flown to Arkalik airport for a reception at the airport by city officials. About 3,000 men, women and children, braving the cold weather, cheered the cosmonauts as the flags of the USSR, India and the Kazhakhistan Republic fluttered in the air.

The cosmonauts were then flown to Baikonour for debriefing and detailed medical check-ups.

Sqn. Ldr. Sharma's son, Kapil, said of his father's achievement: "It is really good. I am so delighted everything was so successful". The Indian cosmonaut's wife, Madhu said: "My cup of happiness is now full to the brim. I am grateful to God and do not have anything more to ask of Him at this moment". In Hyderabad, Sqn. Ldr. Sharma's parents expressed joy and pride at the successful touchdown. They said they were very tense since morning and felt relieved when they got a message 10 minutes after the touchdown.

It was announced in New Delhi on the day of the landing that Sqn. Ldr. Sharma and his two Soviet crewmates Col. Yuri Malyshev and Mr. Genadi Strekalov, have been awarded the **Ashoka Chakra**. Wg. Cdr. Ravish Malhotra in the standby team was honoured with the award of **Kirti Chakra.** This was the first time that the awards were given to foreign maionals.

The Indian and Soviet cosmonauts received congratulations from the President Mr. Zail Singh, and the late Prime Minister, Mrs Indira Gandhi.

In a message addressed to Sqn. Ldr. Rakesh Sharma, the President said: "My congratulations to you on landing safely after successful mission along with your Soviet colleagues."

Mrs Indira Gandhi in her message to cosmonaut Sharma, said: "Welcome back to earth. Every such space adventure is a further step towards knowledge and experience. You have furthered the cause of science and of Indo-Soviet friendship."

Mrs Gandhi said: "Along with the people of India, I congratulate you, your fellow cosmonauts and all others whose joint work made possible the successful completion of your mission."

"We look forward to meeting you in your homeland," the Prime Minister said.

"It is a thrilling experience for the whole mass of humanity in India, because people identified with the brave young man who was up there."

Back in Baikonour, the three cosmonauts were given flower bouquets and greeted with bread and salt in the traditional Russian gesture of welcome. Sqn. Ldr. Sharma planted an elm sapling in the Cosmonauts Avenue on the hotel grounds to commemorate his flight and mark the 23rd anniversary of the first manned space mission accomplished by Yuri Gagarin. The first elm planted by Gagarin himself is now full with strong branches and the avenue is made of elms planted by the cosmonauts from the Soviet Union and fraternal countries who followed him. Each of the elms right up to the one planted by Sqn. Ldr. Sharma is the progeny of Gagarin's elm whose seeds are gathered every year for the cosmonaut nursery. The second elm is the one planted by Leonov, the first man to take a space walk. Sqn. Ldr. Sharma's elm marks the latest step into the unknown.

At an investiture in the Kremlin on 20th April for the heroes of the Indo-Soviet Space mission the late President Chernenko declared that the Soviet Union would share with all nations the results of its accomplishments in outer space. He said that the "Jupiters" (Malyshev, Sharma and Strekalov) of the space mission and the "Beacons" (host crew Kizim, Solovyov and Atkov) showed the whole world what Soviet-Indian friendship had accomplished. He said the two teams had made a new contribution to cosmonautics and were an example of collective work in outer space accomplished in a spirited, efficient and selfless manner.

Mr Chernenko added that there were certain dates in the history of the Soviet Union and India that would always be remembered. April was one month which would not be forgotten as it was in April of 1961 that Yuri Gagarin made the first manned space flight in history and it was in April of 1984 that Rakesh Sharma made the first manned space flight for India.

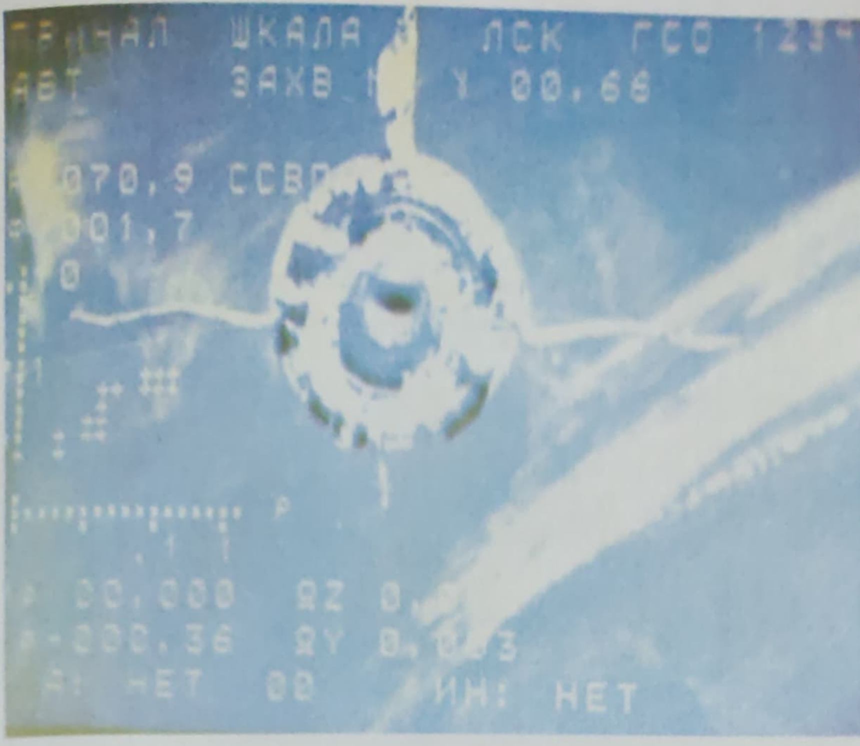
(g) Triumphant Return Home

Sqn. Ldr. Sharma, Col. Yuri Malyshev and Genadi Strekalov and the backup team comprising Wg. Cdr. Ravish Malhotra, Col. Anatoly Berezovoi and Georgy Grechko arrived in New Delhi on 5th May to a red carpet welcome. As the Chief of Air Staff received the cosmonauts, his wife accorded a grand reception to the cosmonauts' wives by garlanding them. When the cosmonauts walked on the shining red carpet, 24 NCC girl cadets, dressed in the costumes of different regions and states symbolising "unity in diversity" greeted them with the Asiad song "Swagatam" to the accompaniment of a shower of rose petals. A group of Soviet girls presented them with bouquets. The Government of India announced on 5th May the award of the **Kirti Chakra** to the two Soviet cosmonauts also in the back up team of the joint space mission, the award of the same to Wg. Cdr. Malhotra having been announced earlier. Later in the day, the cosmonauts as well as Gen. Vladimir Shatalov, Adviser to the Chief of the Soviet Air Force addressed a joint Press Conference.

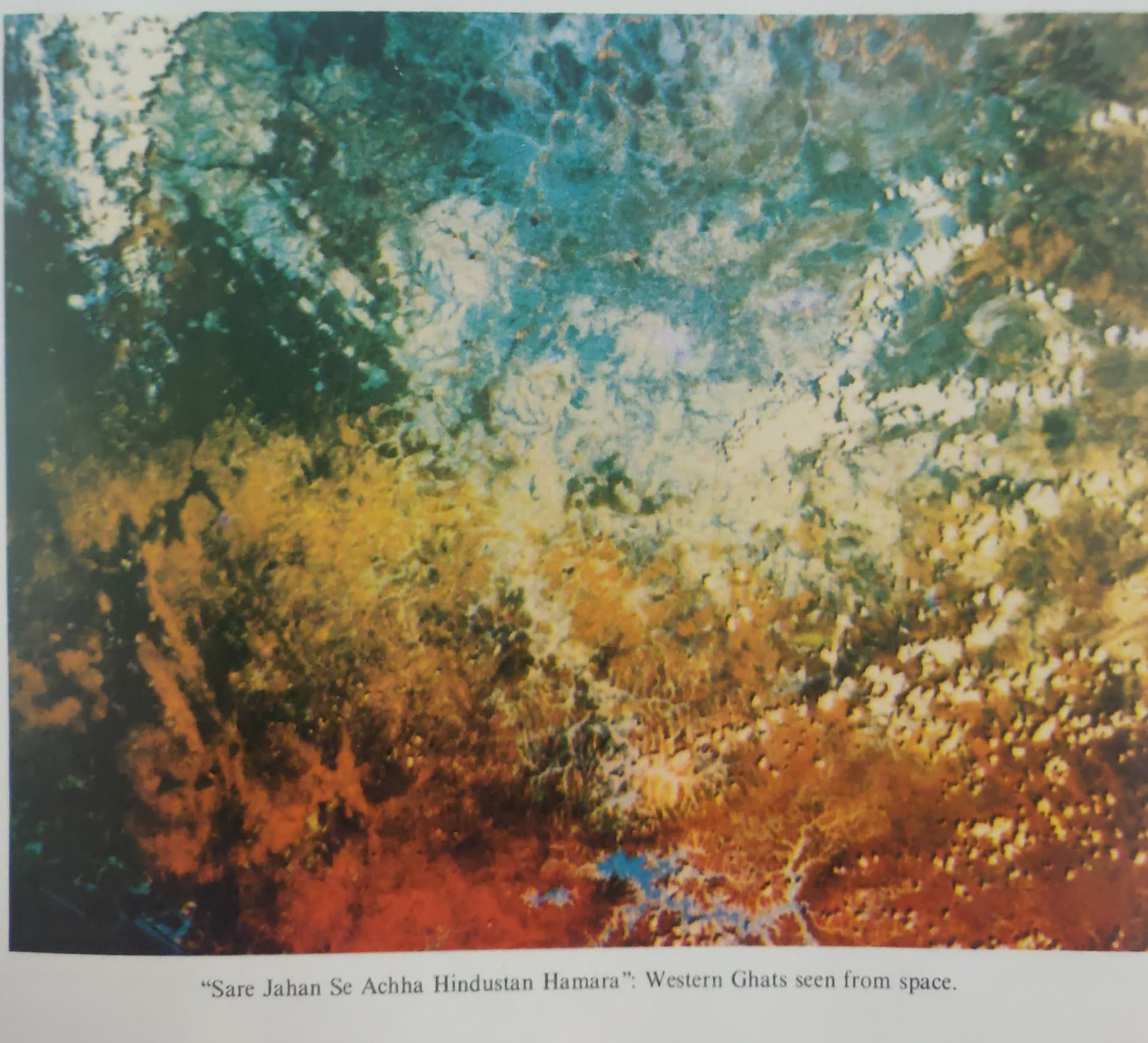
On 11th May, the cosmonauts and their wives, called on President Zail Singh. The Soviet cosmonauts Yuri Malyshev and Strekalov and their stand by colleagues Berezovoi and Grechko presented to the President a photograph of India taken by them during the flight. Sharma and Malhotra presented to the President the combined Indo-Soviet flags which were carried on the flight.

The same day, the cosmonauts were given a civic reception. All of them were given souvenirs-Mysore paintings and silver plates. They were garlanded and lustily cheered by the crowd as they came up on the dais to acknowledge the greetings. They were also treated to a cultural programme.

At a glittering ceremony at Rashtrapati Bhavan on 12th May, President Zail Singh presented the Ashoka Chakra, the highest peace time gallantry award to India's first spaceman, Rakesh Sharma, and to the two Soviet cosmonauts Yuri Malyshev and Genadi Strekalov. The ornate high-domed Durbar Hall packed with dignitaries reverberated with ovation and applause as the President pinned the gold medals tied to a green and orange riband on the left chest of the cosmonauts in their Air Force uniform. Among the distinguished



On April 4, the spaceship SOYUZ T-11 piloted by the Soviet-Indian crew, docked with the orbital complex SALYUT-7 SOYUZ T-10. Photo shows the orbital complex shortly before the docking, photographed via the space telecommunication system.



"Sare Jahan Se Achha Hindustan Hamara": Western Ghats seen from space.

The telebridge Delhi-Moscow- cosmos started operating on April 5, 1984. The late Prime Minister, Mrs. Indira Gandhi congratulated Rakesh Sharma, and the Soviet cosmonauts on the successful start of their work aboard the "Salyut-7" orbital station. Photo shows the Flight Control Centre during a seance of telecommunication with the space crew.

THE FLIGHT OF THE INDO-SOVIET CREW ACCOMPLISHED

(L-R) Indian cosmonaut Rakesh Sharma, Soviet cosmonaut Yuri Malyshev and Soviet cosmonaut Genadi Strekalov after landing on April 11, 1984.

Shrimati Indira Gandhi, at star city seen with the former Soviet Defence Minister, Marshal Ustinov and Sqn. Ldr. Rakesh Sharma.

Presentation of Salyut's capsule to India by Soviet Union. Prime Minister Rajiv Gandhi is seen with the Soviet dignitaries, and the Indian cosmonaut, Sqn. Ldr. Rakesh Sharma, and Gp. Capt. Ravish Malhotra.

gathering were Mrs Indira Gandhi, Mr Hidayatullah, the Defence Minister, Mr. R. Venkatraman and the Soviet Ambassador to India.

First to receive the medal was Cosmonaut Malyshev, Commander of the Soyuz spacecraft. He was followed by Rakesh Sharma and cosmonaut Strekalov.

President Zail Singh presented the Kirti Chakra to the Soyuz stand-by crew, Col Antoly Berezovoi, Ravish Malhotra and Georgi Grechko.

The citation described Rakesh Sharma as one who "has displayed most conspicuous daring and courage to become the first Indian to go into space."

The **Kirti Chakra** citation for Malhotra said that he kept himself in a state of complete preparedness. It said: "Wg. Cdr. Malhotra, during his entire period of training has displayed conspicuous gallantry and courage".

Felicitating the Soviet and Indian cosmonauts the President said, "The people of both our countries rejoice in your outstanding achievement. Your example will inspire millions of young citizens in our two countries to reach out for the distant". The President conveyed his "very special felicitations" to the Indian Air Force for providing two of its outstanding members for the space flight. Pointing out that India's space programme was dedicated to peaceful use of outer space, the President described the joint space flight as a "fine testimony to the friendship between our two countries."

Mr Zail Singh said India was grateful to the Soviet Union "for the firm hand of cooperation" and hoped it would continue to grow in the field of space research.

The **Ashoka Chakra** medal has on one side the replica of Ashoka Chakra surrounded by a lotus wreath. The words "Ashoka Chakra" are embossed in Hindi and English on the reverse side. The silver **Kirti Chakra** medal has a replica of Ashoka Chakra embossed on one side and the words "kirti chakra" in Hindi and English embossed on the reverse.

Immediately after the ceremony, Mrs Gandhi chatted with the cosmonauts and posed for group photographs.

There was a public reception for the Indian and Soviet cosmonauts in New Delhi on 13th May under the auspices of the Friends of Soviet Union. Mr K.R. Ganesh, a former Union Minister, read out a message from Mrs. Indira Gandhi saying: "The friendship between India and the Soviet Union is a model of international cooperation between the two States with different backgrounds and social systems. By working together on the ground during training and in the cosmos, Soviet and Indian cosmonauts have cemented relations between our two countries."

Talking about space exploration Mrs Gandhi said, "Space is humankind's newest frontier. Its exploration uses the finest attainments of science and technology. This vast uncharted area has not yet been fragmented into boundaries. It belongs to all people of the earth".

VIII. Experiments in Space

(a) **Introduction**

The Indian and Soviet cosmonauts carried out a series of important experiments during their seven day odyssey aboard the Salyut-7. The technological experiments were of two kinds; those intended exclusively for the needs of space exploration and those designed to solve some of the mundane problems. The first group included research in the generally known technological processes such as welding, soldering, cutting metals and coating. The second group of experiments included the manufacture of semi-conductors, optical glasses and other link material used in many scientific instruments. Besides these two types of experiments, the Indian cosmonaut carried out scientific experiments of interest to the Indian Air Force and research institutions. Much of the biomedical investigations, sponsored by the Institute of Aerospace Medicine in Bangalore was related to the effects on humans of the microgravity environment which exists in space. Aspects such as cardiovascular deconditioning, space sickness and disturbance of motor function were investigated along with measures to counter them. Sqn. Ldr. Sharma also carried out an extensive programme of taking photographs of Indian territory as an aid to assess the natural resources of the country.

In weightlessness, a smelted metal behaves unlike that on earth. The usual tools and instruments like screw drivers, saws, drill and hammers cannot be used in space. Weightlessness in space create special problems which are never felt on earth. For example, fixing a nail with a hammer is an easy task on earth but the same operation carried out in space will cause a big reaction, even throwing the cosmonaut out into the empty space. A special hammer designed for use in space, has hollow heads filled with metal shots. This design makes it possible to exert the maximum force on the nail to be hit while preventing at the same time the reaction from being directed towards the operator holding the hammer. Similarly, if an ordinary drill is used to make a hole in a metal block in space, the reaction produced might make the cosmonaut spin in the opposite direction. Hence the drill for use in space is provided with a counter-balancing torque to keep the cosmonaut stable. The other tools included in the new design are nippers with rubber loops to seam them to the groves of the cosmonauts' space suits and a soldering iron resembling a ball-point pen. The Indo-Soviet crew carried aloft to the Salyut samples of the as yet unmelted silver and germanium elements for the undercooling experiment. The tools carried by Sqn. Ldr. Sharma weighed about 17 kg.

The experiments conducted by Sqn. Ldr. Sharma in space were sponsored by various Indian institutions. For instance the experiment on the "undercooling" of silver-germanium alloy, was carried out under the aegis of the Defence Metallurgical Research Laboratory and ISRO sponsored the "Terra" experiments on remote sensing. The bio-medical aspects of space flight were studied on behalf of the IAF. Sqn. Ldr. Sharma also performed certain

selected yogic exercises to assess their efficiency in countering the effects of weightlessness.

(b) **Undercooling of Silver-germanium Alloys**

This experiment called Isparital was the most exciting from the point of view of the scientific community. It was also all important for the nation's economy. According to Dr. V.S. Arunachalam, Scientific Adviser to the Raksha Mantri silver-germanium alloy can be used as a transformer core and its power to conduct electricity would be so high, that tonnes of metal could be replaced by a few kilogrammes, thus saving crores of rupees. Such an alloy is also corrosion free. France had tried this experiment reportedly with no great degree of success. Manufacturing such an alloy by undercooling is considered so important that in the USA, no foreigner is allowed on this project, according to Dr. V. Arunchalam.

Crystalline silver-germanium alloy is a well known alloy whose only use, as of now, is in plating crockery. What Sqn. Ldr. Sharma attempted in space was the making of an amorphous solid alloy of germanium and silver instead of the usual crysatalline alloy. An amorphous solid is much more strong than a crystalline solid. But all solids as they are formed, tend to crystallise.

An alloy is formed by melting two metals, mixing them in one vessel in a molten condition and allowing the mixture to cool. When the mixture cools, it forms its own crystalline structure of the two metals comprising the mixture. Dr. Arunachalam explained that Sqn. Ldr. Sharma tried to avoid the formation of this mixture. He explained that the crystals are first formed when the nuclei of the two metals get together in an ordered form due to gravitational convection. If there were no gravitation, the nuclei would not tend to crystallise. So Sqn. Ldr. Sharma was trying to "undercool" the alloy as it solidified, cooling it extremely slowly, the idea being to cool it as far as possible before it crystallised so as to get as solid an amorphous material as possible.

Dr. Arunachalam explained that in space, the alloy could be cooled to a much lower temperature than on earth and still remain amorphous. Normally, the crystals form on the surface of the vessel in which the mixture is cooled. If the vessel is dispensed with before cooling, the formation of crystals can be slowed down. What Sqn. Ldr. Sharma did was to take the liquid alloy out of a vessel before the cooling so that there is no surface against which the crystals could form. This can be done only in space where there is no gravity. Nowhere else can a liquid be kept out of a vessel.

Silver and germanium have some properties which make them eminently suitable for making an amorphous alloy. The two have very nearly the same melting points, silver 960.5 degrees centigrade and germanium 959 degrees centigrade. Moreover germanium has the capacity to function as a rectifier and conducts electricity in one direction only. Silver also has some special chemical properties. For instance, it excels all other metals as a conductor of electricity. For these reasons, scientists have been trying for years to make an amorphous alloy of silver and germanium. If Sqn. Ldr. Sharma's experiment has been successful it will open up a new vista of opportunities in industrial applications.

(c) **Experiment "Terra" on Remote Sensing**

The objectives of this experiment sponsored by ISRO included photography of the Indian territory with highly sophisticated cameras. Salyut-7 is equipped with cameras that clearly see ground objects of the size 30 metres and above. The Multi-Spectral camera MKF-6M which operates in six bands, four of them in the visible range and two in the near infra-red range, was made at the famous Carl Zeiss Jena optical factory in the German Democratic Republic. Salyut-7 is also fitted with KATE-140 cartographic camera. This provides single band, panchromatic black and white or infra-red black and white imagery on aerial film rolls. Films taken during the mission are expected to yield valuable ancillary data and assist in analysis and interpretation in the fields of forestry, land use mapping, cartography, oceanography, geology and coastal monitoring. A unique feature of the camera equipment in Salyut-7 is what is described as "sterio-photography", taking two frames of the same location from two different points. This would enable researchers later to determine the actual height of ground objects like towers, hills and mountains. Sqn. Ldr. Sharma has covered 40 per cent of Indian territory. About 90 per cent of the forest cover of Andaman and Nicobar Islands, has also been covered.

The "Terra" experiment, details of which have been given in the previous section, are expected to yield film images of very good quality to be analysed by conventional photo-interpretation techniques. All data obtained by the Indian researcher cosmonaut will be shared by India and the Soviet Union and processed jointly.

(d) **Biomedical and Cardiovascular Investigations**

Biomedical investigations are important in order to gain an insight into the physiological stresses and associated psycho-physiological disturbances and thereby develop effective counter measures to promote the efficiency of the cosmonauts as well as make their safety doubly sure. Experiments were conducted to study the effect of space flight on cardiovascular system, space sickness and motor functions.

Some of the equipment developed by the Hindustan Aeronautics Limited for the cosmonauts' use for vectocardiography was in operation. Its purpose was to measure the cosmonaut's response to space sickness. The HAL, which has so far produced equipment of the aircraft standards, produced such spacecraft standard equipment for the first time.

Ballisto-cardiography studied the body movement in response to ejection and flow of blood due to heart contraction to assess haemo-dynamic functions. Recording of three-dimension mechanics under conditions of weightlessness will provide valuable data on the changes in circulation under weightlessness.

Previous manned space flights have confirmed that weightlessness produces harmful effects on the vestibular system of some subjects. In the initial period, this usually manifests itself in disorientation and, in some cases through symptoms of space sickness. This can affect the overall performance of the cosmonauts. Weightlessness is associated with reduced activity and tension in the muscles due to decrease in loads on the musculoskeletal system. Earlier manned space flights had confirmed that cosmonauts can perform complex

operations in space. For the first time, certain **yoga asanas** were taught to the Indian cosmonaut to study what effect they had on the discomforts associated with weightlessness.

(e) Yoga Exercises

The yoga experiments, which involved collection of diverse data during a daily ten minutes of yoga exercises by Sqn. Ldr. Rakesh Sharma included the studies of his biomedical conditions while performing, for two minutes each the five selected **yoga asanas**. The purpose of the experiment was to study whether yogic exercises can supplement or replace the special space exercises which the cosmonauts have to perform to prevent space sickness and ensure that their muscular and cardiovascular systems do not atrophy and waste during voyage.

Sqn. Ldr. Sharma stood the condition of weightlessness admirably. The then Director of Medical Services of the Indian Air Force, Air Marshal Mulk Raj, struck a note of caution however, saying that any data from a single flight could at best be indicative and not conclusive. The Chief of the Soviet Institute of Biomedical Sciences, Dr. Arkady Yeryomin, said that any positive indicators about yoga could encourage the Russians to ask their own cosmonauts to adopt, if not the entire yoga system, some rational aspects of these Indian exercises. Nevertheless, he was of the view that results would have to be watched and carefully evaluated. The major point of interest was whether a course in yoga added to the training, would help condition spacemen better to withstand the emotional stresses of space journey as well as its demands on the body. The second point of interest for the Soviet scientists was whether yoga could help counteract the dysfunction in the vestibular system, the unevenness of blood flow and the diminution of muscle response to stimulii. The Soviet scientists have several exercises designed to counteract these manifestations and also drugs, but were unsatisfied with the results of the use of these techniques. With the idea of making space flights a permanent feature for industrial and scientific purposes, they would normally like to find still better methods. It was here therefore, that they would want to see whether yoga would help. There were also certain effects on spacemen which Soviet scientists had not been able to remedy. For instance, the motion in space affects the ocular function considerably even though the function becomes normal after a day or two. Here again yoga could come to their rescue.

(f) Indian Food Items for Space Crew

Some typically Indian food items were included in the diet during flight of the space crew. The items were développed by the scientists of the Defence Food Research Laboratory, Mysore. They were tested by the soviet Institute of Bio-medical Sciences before they were approved for inclusion in the space menu of the Cosmonautes. The items were shared by Sqn. Ldr. Sharma with his five Soviet Cosmonaut colleagues.

The four items which were introduced into the speacemen's menu from India were orange juice, mango juice, mango bars and banana crisps.

It has been explained that the four Indian items of food were selected for the spacemen's menu after rigorous study and testing by both the Indian and the Soviet scientists for ensuring that the spacefood developed by the scientists of the Defence Food Research Laboratory, was completely microbe free. The Indian team of defence food scientists was the same which had earlier developed food included in the survival kits of high altitude sportsmen and soldiers in India as well as members of the Indian Antarctic expeditions.

IX. Through the Eyes of A Spaceman

—By Rakesh Sharma

I had the good fortune of being selected to go up in space. I wish to emphasise that it was sheer good fortune because between my colleague Wg. Cdr. Ravish Malhotra and myself, I can lay claim to no special quality that was present only in me and not in him.

Indeed it was an opportunity of a lifetime and only a very few in the world have been fortunate enough to see their planet from a height of 300 Kms. While aware that the eyes of the whole nation were on me, I decided to make the most of this opportunity which had come my way.

My first impression on observing the Earth below, was to marvel at the immensity of the scale at which things were actually in. It was difficult to imagine that everything had come to pass as a result of a great cosmic accident. It was a sobering thought and reinforced the possibility of a superior force having caused it to happen. The natural beauty evident was breathtaking. Man made boundaries and borders could not be observed and it became difficult to understand the reason for the presence of tension in the peaceful looking planet.

The colours of natural features were accentuated by day and by night, cities looked like a bunch of dull and diffused pools of light. India looked splendid as I passed over it twice every day. Crossing over from the deep blue Indian Ocean, I could see the green of the South merging with the brown land mass of the Central region, finally giving way to purple Himalayas capped with brilliant white snow

Stars, when viewed from space, appear as pin points of light and do not twinkle as they do when observed from Earth. This is because the atmospheric blanket is absent and does not come in the line of sight when celestial objects are viewed from space. Easily the most beautiful and memorable sight was that of observing sunrise and sunset from space.

I have been questioned often whether I experienced 'space shock' much as other people experience culture shock. It was not so because months of training and thinking about the event that was to come had adequately conditioned my mind and I knew what to expect. Further, there is so much of general information available on the subject that one is able to mentally perpare oneself tor the experience. Being interested in the subject of space for years, I had been following the developments in Space Technology pretty closely.

During my eight days in space, travelling at a speed of 8 km per second, I logged a distance of approximately 5,529,600 kms! However, one did not feel travel weary or homesick. It was work as usual. Six of us milling around and our work was charted out to the last minute, leaving no time for either boredom or reflection. During our stay in the Salyut laboratory, we performed Earth Resources, Material Science and Biomedical experiments. Experiment Terra called for photographing a large part of the country by the remote sensing technique.

The photographs will provide a wealth of information which can be used for the search and development of natural resources in the country. The results, therefore, should have a far reaching effect on the national economy. In the material science experiment, a sample of silver-germanium alloy which was melted in space, was brought back for analysis. Yoga was a part of the biomedical experiment package. It was selected in the hope of finding a solution to the long standing problem of space sickness—a solution that has been eluding both American and Soviet scientists ever since the advent of manned space flight. Analyses of results obtained is fast nearing completion and should throw up some interesting facts.

Our orbital home had everything designed to make our stay as natural and comfortable as possible. For example, each crew member could select the food of his choice. I could float effortlessly from one corner of the space laboratory to another, but it becomes difficult for a person who has not experienced it to visualise the kind of effect it can have. We attempted to demonstrate this during one of the TV reports from space when I asked one of my colleagues to let me have a camera. He just pushed it on towards me and it floated gently into my hand. Zero gravity, though a pleasurable sensation, presented some unique problems. Brushing of teeth required the cosmonaut to stick his toes into straps to keep from floating away. It was necessary to anchor oneself while performing any task whatsoever. Food required special receptacles and special processing to ensure the right packing density. Fluids were packed in tubes.

Indeed the only hurdle in setting up a "civilisation in space" would be the absence of gravity as prolonged stay in this environment leads to decalcification of bones. Scientists are toying with the idea of creating artificial gravity on future space colonies but the existing state of technology does not permit such a solution.

I am convinced that the future of planet Earth lies in outer space. The youth today belong to a lucky generation which will be viewing stupendous advances in space technology during their lifetime. It follows then, that they must prepare themselves for the technological jump that is sure to come, that they must take up space related sciences and aim to achieve excellence in their chosen field.

X. Biographical Sketches of Indian and Soviet Cosmonauts

Col. Yuri Vasilevich Malyshev : Hero of the Soviet Union, pilot astronaut of U.S.S.R. was born on 27th August 1941 in the city of Nikolaevsh in the Volgagrad district. After finishing Kharkovskoe Military Aviation Higher School, he served in the Air Force and became a specialist in some types of aircraft. He earned the qualification of Air Force pilot of first class and Testing pilot of third class

Yuri Malyshev has been a member of the Communist Party of the Soviet Union since 1964.

In the team of astronauts since 1967, he has finished the complete course of preparation of space flight on different piloting apparatus. He performed his first space flight as a Commander of a crew of spacecraft "Soyuz-T-2" from 5th to 9th June 1980. In this flight V.V. Absenov, pilot astronaut of U.S.S.R. was the flight engineer. The crew of the spacecraft for the first time carried out the flying test of new navigation systems and allied apparatus with a view to improve the system of transporation of spacecraft, Soyuz-T, its piloting qualities and automatic docking mechanism which performs the docking manoeuvre with the orbital scientific research unit "Soyuz-36".

Yuri Malyshev is married and has two children. His wife Nagezlida Vasilevna is a medical servant who is working in the polyclinic of star city. Their son, Andrei is a student of the second course at the Moscow Institute of Chemical Machine building and their daughter Natasha, is a student of middle school.

Yuri Malyshev is interested in art photography and sports. He plays tennis, football and also swims. He collects the monograms of aviation and cosmonatics as an additional hobby.

Rakesh Sharma is a Squadron Leader, equivalent to major in the Indian Army. He was born on 13th January 1949 at Patiala in Punjab. He gave up his undergraduate course at the Nizam College, Hyderabad in 1965 to join the National Defence Academy, Khadakvasla, as an Air Force Cadet. After four and a half years of training he was commissioned into the Indian Air Force on 13th January 1970. He subsequently served in different operational squadrons of the Air Force and took part in the 1971 operations during which he flew several missions on Mig aircraft. He has undergone an Experimental Test Pilots Course at the Aircraft and Systems Testing (Evaluation) Establishment at Bangalore. He has flown for over 1600 hours on several types of aircraft, including many Mig variants, Ajeet, Marut, Hunter, Canberra, HS 748, Caribou, Iskara, Kiran and the HPT-32. He is married and has a son, Kapil Sharma, aged 9 who is at school. His hobbies are reading, music, cricket, squash and tennis. His wife Madhu is an interior designer and was working at Bangalore before joining her husband at Star City.

Genadi Mikhailovich Strekalov : Hero of the Soviet Union, Pilot Cosmonaut Genadi Mikhailovich Strekalov was born on 28th October 1940 in the town of Mitishi of Moscow Region. He graduated from Bauman Technical Institute in 1965 and now works in design bureau dealing with the design of space flying equipment. He has been a member of the Communist Party since 1972. Joining the ranks of Cosmonauts in 1973, he successfully mastered all types of space equipment. He has already participated twice in space flights. First, he was in a space flight from 27th November to 10th December 1980 as test-engineer on Soyuz-T-3 along with Commander L.D. Kizim and flight engineer O.G. Makarov. Soyuz T-3 had docked with Salyut-6, Progress-11. In the 13 days flight the crew did a lot of repair and restoration work on Salyut-6.

From 20th to 22nd April 1983, he was in a second space flight as flight engineer on 'Soyuz-T-8' with Commander V.G. Titov and Cosmonaut researcher-A.A. Siribrov. In this flight, during proximity of Soyuz to Salyut, deviation from the norms was observed and docking was abandoned.

Genadi Strekalov is married and has two daughters. His wife Lidia Anatolievna works as leader of a group in one of the design institutes of Moscow. Their two daughters, Tatiana, born in 1974 and Natalia born in 1975, are both at school.

Strekalov is a member of the Central Committee of VLKSM and Chairman of the Federation of Water-motor Sports of RSFSR. He has been participating in mountain-skiing sport for the last 20 years.

Colonel Anatoly Nikolaivich Berezovoi : Hero of the Soviet Union, pilot astronaut of USSR, Col. Anatoly Nilolaivich Berezovoi was born on 11th April 1942 in the town of Enem of Oktyabpsky district of the Agigerisky autonomous region. After completing middle school he worked as a lathe operator in the "Neftemash" workshop in the city of Novockerkassk of the Rostovsky region.

In 1965 he passed out of the Karinskir higher school and served as a pilot in the Air Force. He became a specialist on some types of aircraft. He qualified as an "Air Force pilot, First Class". Since 1970 he has been enlisted in the team of cosmonauts. Anatoly Berezovoi has undergone a complete course on preparation for space flight on different spacecraft. In 1977, he passed out from the Air Force Academy named after Y.A. Gagarin without disturbance of his main assignment.

From 13th May to 10th December 1982, Anatoly Berezovoi completed his first space flight with engineer, pilot cosmonaut of the USSR, VV Lebedev, and Mission Commander of the crew in spacecraft, 'Soyuz-T-5' and orbital station Salyut-7. This flight which lasted 211 days became the world record for the longest stay of any cosmonaut in orbit.

On 24th June 1982, spacecraft Soyuz-T-6 with an International crew on-board consisting of Commander of the mission Colonel VA. Dzhanibekov, flight engineer and pilot cosmonaut of USSR, AF. Ivanchenkov and cosmonaut researcher and citizen of the French Republic, Col. Jean Loup-Chretien, docked with scientific orbital complex Soyuz-T-5/Salyut-7. This crew worked in the complex upto 2nd July 1982.

On 20th August 1982, Soyuz-T-7 consisting of Commander of spacecraft, pilot cosmonaut of USSR, Colonel. L.I. Popov, flight engineer AA. Serebrov and cosmonaut

researcher Ms. S.E. Savitskaya, docked with the orbital complex. They carried out their scientific programme for more than seven days together with Berezovoi and Lebedev.

During the flight in the Station 'Salyut-7' cosmonauts Berezovoi and Lebedev carried out an EVA (Space walk) lasting more than a couple of hours.

Anatoly Berezovoi is married and has two children. His wife Lidia Grevgorovna, is a reader in the Department of History of the KPSS of the Moscow All Union Civil Engineering Institute. His son, Sergei, is a student of the middle school. His daughter, Tamyana is a student of the primary school.

Anatoly Berezovoi is interested in art photography and wood carving and likes to ski, swim and play tennis.

Ravish Malhotra is a serving officer of the Indian Air Force holding the rank of Wing Commander, the equivalent of Lieutenant Colonel in the Indian Army. Born on 25th December 1943 at Lahore, now in Pakistan, he went to St. Thomas High School, Calcutta where he passed the Senior Cambridge examinations. He joined the National Defence Academy, Khadakvasla, as an Air Force Cadet in 1959. After four years of training, he was commissioned into the Indian Air Force on 23rd October 1963. He had served with distinction in various operational squadrons and flew several operational missions in Sukhoi aircraft during the 1971 operations. He undertook an Advance Weapons Course in the United States on F-86 and T-33 in 1964, the Flying Instructors course in December 1970, the Experimental Test Pilot Course in the United States in December 1974, and the Defence Services Staff Course in 1977. He has over 3400 hours of flying to his credit and has flown a wide variety of aircraft including Vampires, Mysteres, F-86, T-33, Phantom, T-38, A-37, B-52,, F-111, F-106, Sukhoi-7, MIG 21 variants, Canberra, HT-2 and the Kiran. At the time of selection as a cosmonaut, he was Officer Commanding, Test Pilots School. He is married and has a daughter, Rakhee aged 10 and a son Rohit, aged 8. Both the children are at school.

Georgi Mikhailovich Grechko : Twice Hero of the Soviet Union, pilot astronaut of the U.S.S.R., Georgi Mikhailovich Grechko was born on 25th May 1931 in the city of Leningrad. In 1955, he passed out with distinction from the Leningrad Mechanical Institute. He works in the design office where he takes part directly in the development and testing of new items of space equipment. He has a degree in engineering. Georgi Grechko is a member of the Communist Party of the Soviet Union since 1960.

He enlisted in the team of astronauts in 1966. He has successfully undergone the course of training for flight on different types of space flight equipment. Before the Indo-Soviet manned space mission, he took part thrice in space flights as a flight engineer. He completed his first 30 days space flight from 11th January to 9th February 1975 in the spacecraft Soyuz-17 which docked with the orbital scientific station Salyut-4. The Commander of the crew of that mission was Colonel A.A. Gubarev. During the flight, the astronauts carried out a large number of studies of the sun, planets and stars in the different ranges of the electro-magnetic radiation spectrum.

The second space flight performed by Georgi Grechko, together with Col. Yuri Romanenko in spacecraft Soyuz-26, along with orbital station Salyut-6 was from 10th December 1977 to 16th March 1978. The flight continued for 97 days and was an endurance

record in its time. In this flight, for the first time in the history of world cosmonautics, the docking with the orbital complex was done automatically by a cargo spacecraft, Progress-1, transporting new scientific equipment and materials which were vital for the crew and fuel for the orbital station. Also, for the first time in the history of cosmonautics, the full scientific complex linking three spacecraft was created, with Soyuz-26 and Soyuz-27 linking with the orbital station Salyut-6.

Spaceship Soyuz-27 brought on the orbital space station crew commander Lt. Col. V.I. Dzhanibekov and the on-board engineer O.G. Makarov. This crew remained on the orbital flight from 10th to 16th January 1978. During this period, for the first time, four cosmonauts worked in the scientific complex simultaneously.

From 3rd to 10th March 1978 on the orbital complex in which U.V. Romanenko and G.M. Grechko continued their flight, the first international crew, with commander of the spacecraft A.A. Gurvarav and cosmonaut researcher of Czechoslovakia, Vladimir Remela worked.

G.M. Grechko and U.V. Romanenko completed a large volume of scientific investigation of atmosphere and inosphere of earth on board the orbital station. They conducted technological experiments on obtaining various materials in the condition of weightlessness and during work for an hour and a half in the open space tested new type of space pressurised suits.

Georgi Grechko is married and has two sons. His wife Maya Grugorevna works as teacher of English language. The elder son Alexy works in the Department of International Air Information and the younger son Mikhail has finished the course as engineer of civil aviation from the Moscow institute.

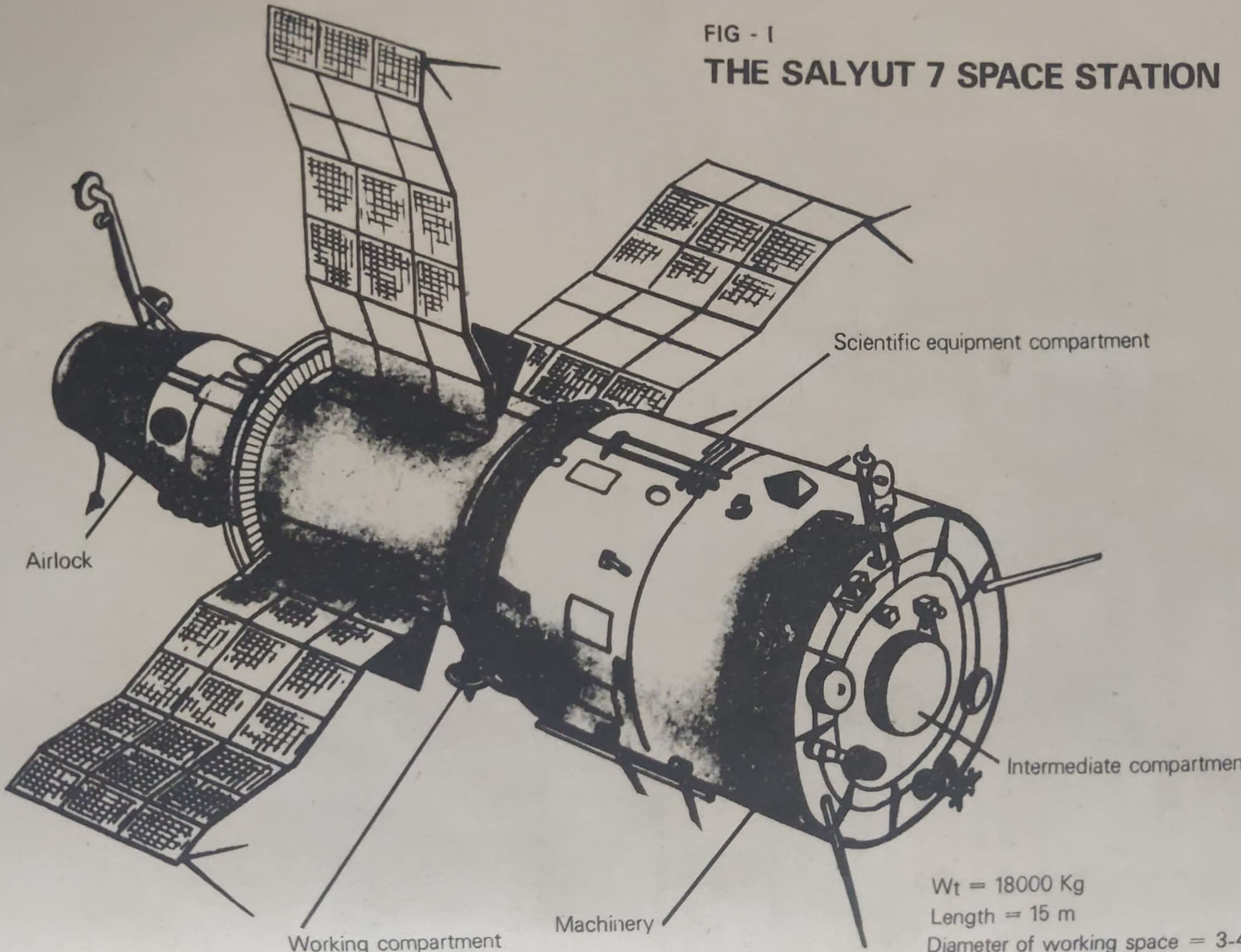
Georgi Grechko is a master in autosports and also likes mountaineering, skiing, sports and scuba diving.

XI. Indian Organisations and Laboratories who Took Part in the Joint Space Mission

The Indian Air Force	—Cosmonauts, space cell and MIC
Institute of Aviation Medicine (I A M)	—Biomedical experiments
Hindustan Aeronautics Ltd. (HAL) (Electronics Division)	—VCG Modules
Defence Food Research Laboratory	—Space Diet for Indian Cosmonauts
Indian Space Research Organisation, ISRO	—'Terra' Remote Sensing Experiment
Doordarshan, India	—Telecast of Space Mission
Department of Posts and Telegraphs (Communication)	—Satellite link between USSR and India for TV coverage and internal communications. Postage Stamps and Covers for space-mail activity.
Overseas Communication Services	—Satellite link between USSR and India for voice and teletype links.
AIR	—Commentary and interviews
FDI	—Documentary film coverage.
DMRL	—Material Sciences Experiment.
Space Cell (Air HQ VB)	—Co-ordinating agency for the project from Indian side.

FIG - I

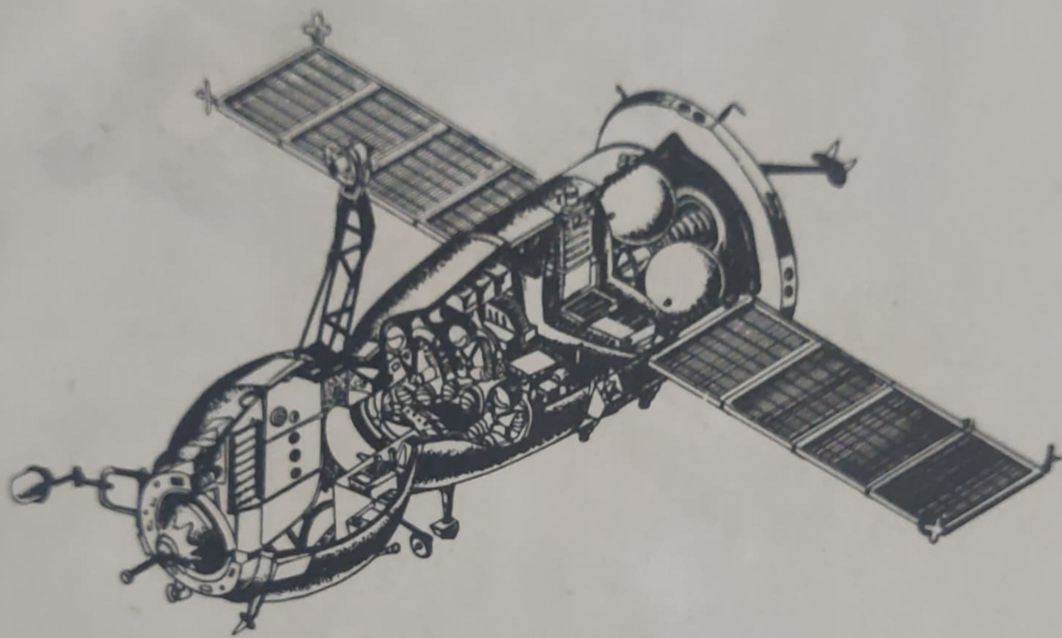
THE SALYUT 7 SPACE STATION



Wt = 18000 Kg
Length = 15 m
Diameter of working space = 3-4 m

FIG - II

SOYUZ T SPACECRAFT

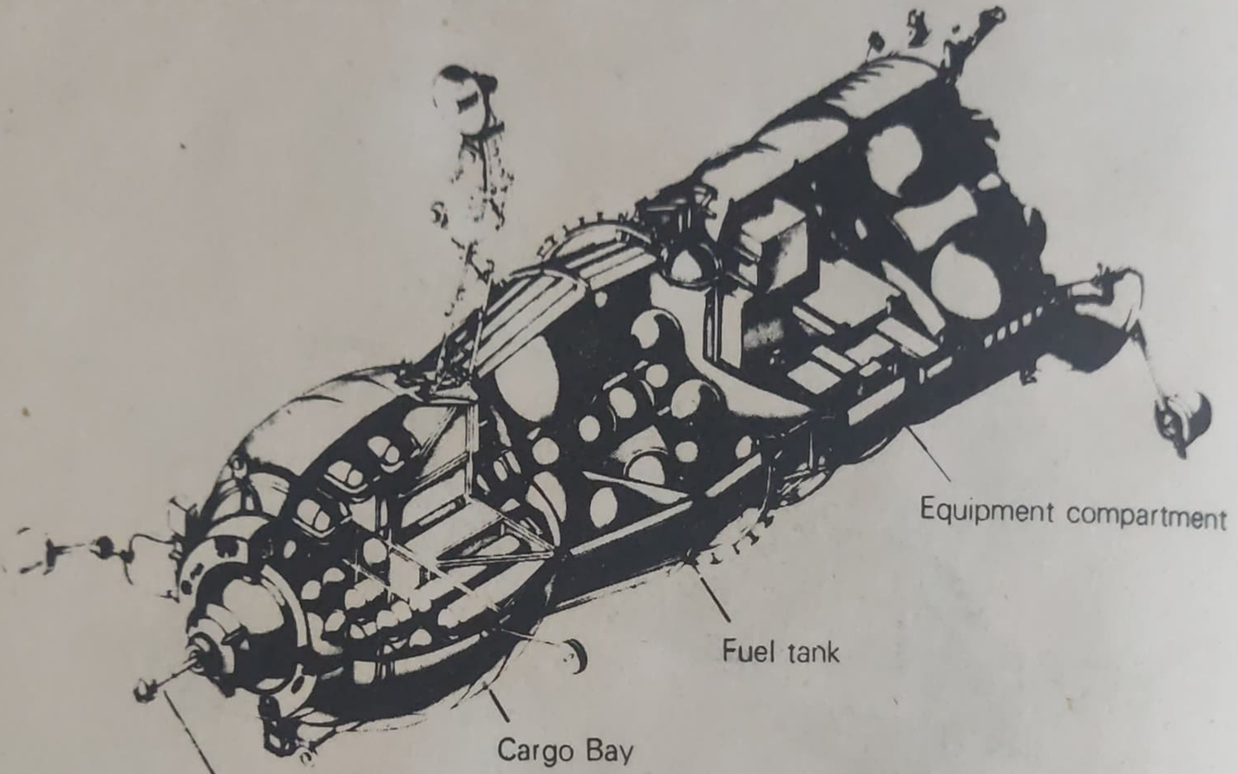


PRINCIPAL CHARACTERISTICS

Crew	2-3 persons
Weight	6 850 kg
Weight of descent module	3 000 kg
Length of the body	6.98 m
Maximum diameter	2.72 m
Span of extended solar battery panels	10.6 m
Type of booster rocket	Soyuz

FIG - III

THE PROGRESS SUPPLY VEHICLE



FUNDAMENTAL CHARACTERISTICS

Spacecraft weight : 7020 kg
payload carried : 2300 kg
including :
— in the transport section : up to 1300 kg
— in the component section before resupply : up to 1000 kg
Max length : 7.94 m
Max diameter of sealed sections : 2.20 m
Type of launcher : SOYUZ
Flight time :
— autonomous : up to 3 periods of 24 hours
— with the orbital space station : up to 30 periods of 24 hours
Orbital parameters :
— altitude 200-350 km
— inclination 51.6°
— period : ~89 mn

FIG - IV
THE MULTI-SPECTRAL MKF-6 M CAMERA

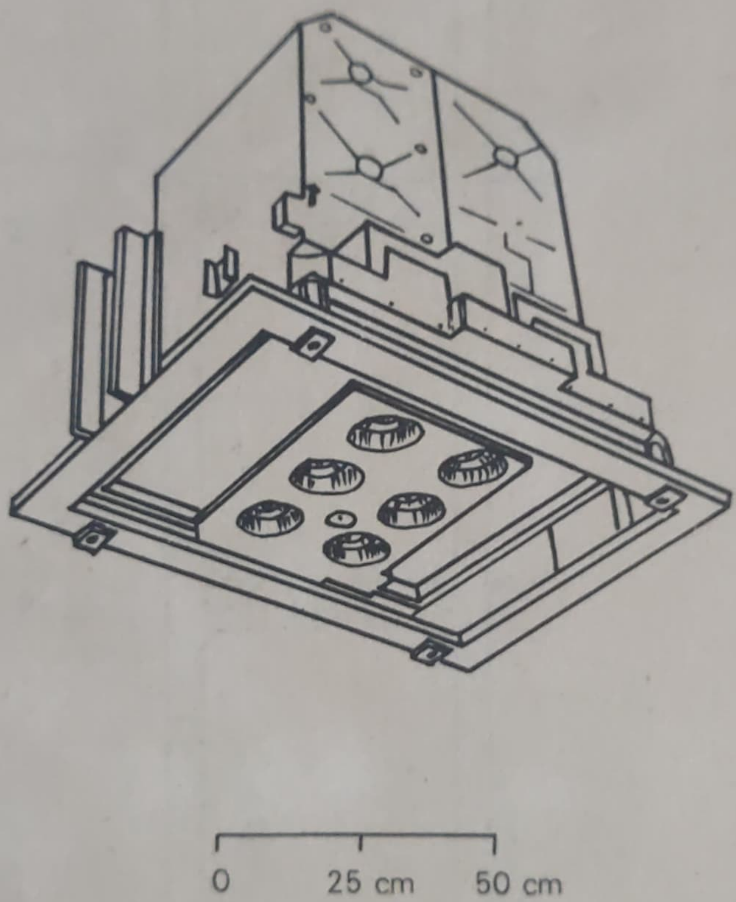


FIG - V

SKETCH OF THE INDIVIDUAL IMAGE FRAME

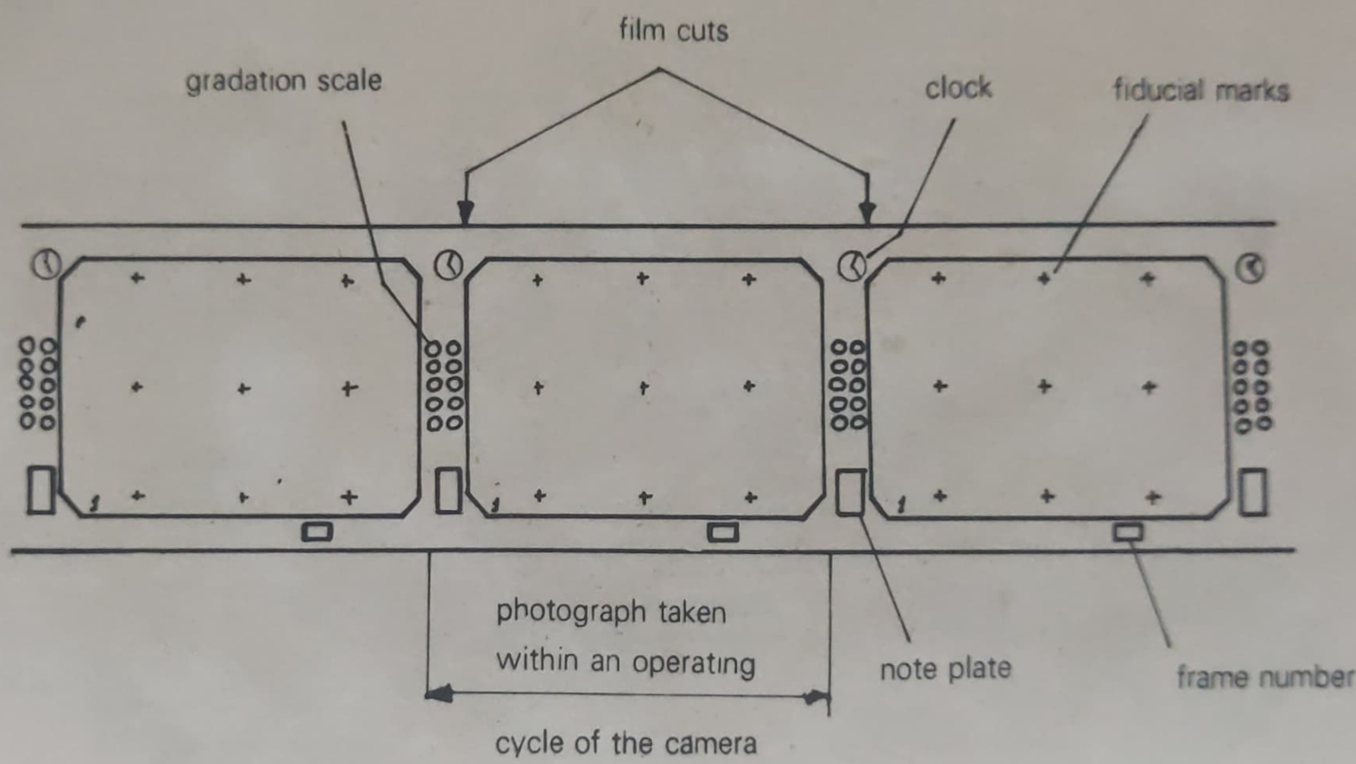


FIG - VI
(a) FILTER TRANSMISSION AND CHARACTERISTICS
(b) OVERALL TRANSMISSION FOR THE
SIX MKF - 6 M BANDS

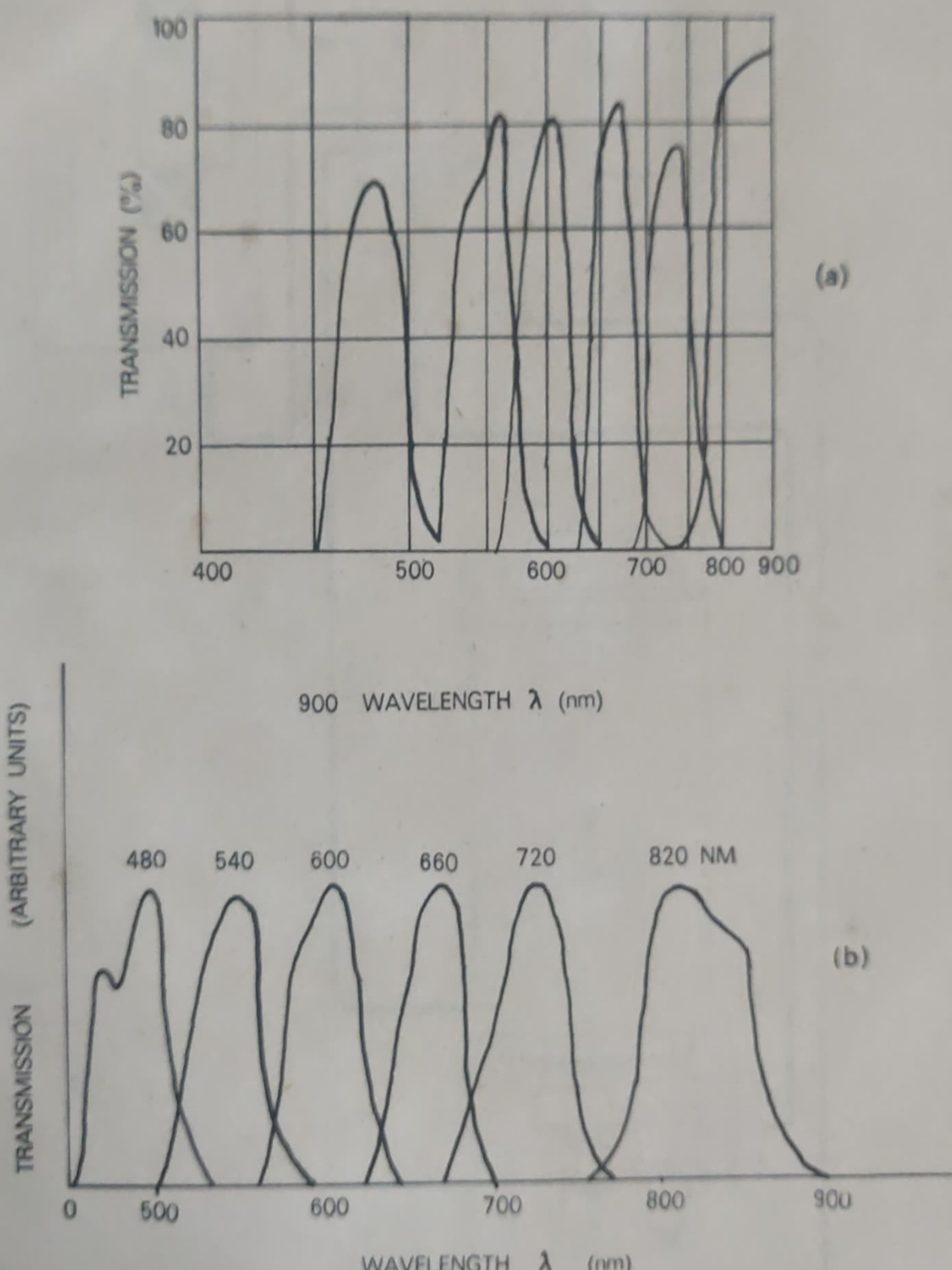


FIG - VII
MATERIALS